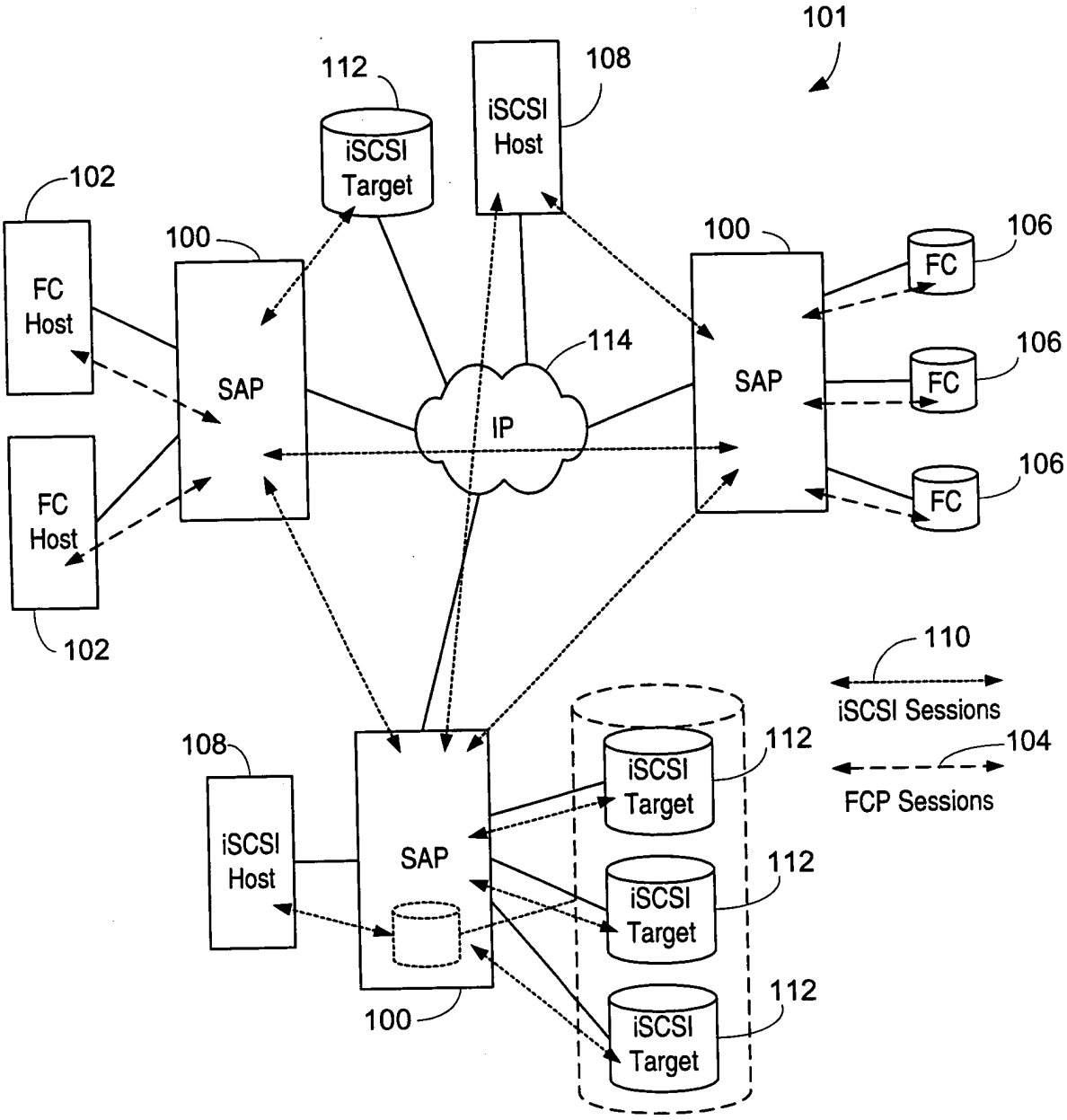
101
112
iSCSI Target
108
iSCSI Host
102
FC Host
100
SAP
114
IP
100
SAP
106
FC
106
FC
106
FC
FC Host
102
110
iSCSI Sessions
104
FCP Sessions
108
iSCSI Host
SAP
100
112
iSCSI Target
112
iSCSI Target
112
iSCSI Target

FIG. 1A

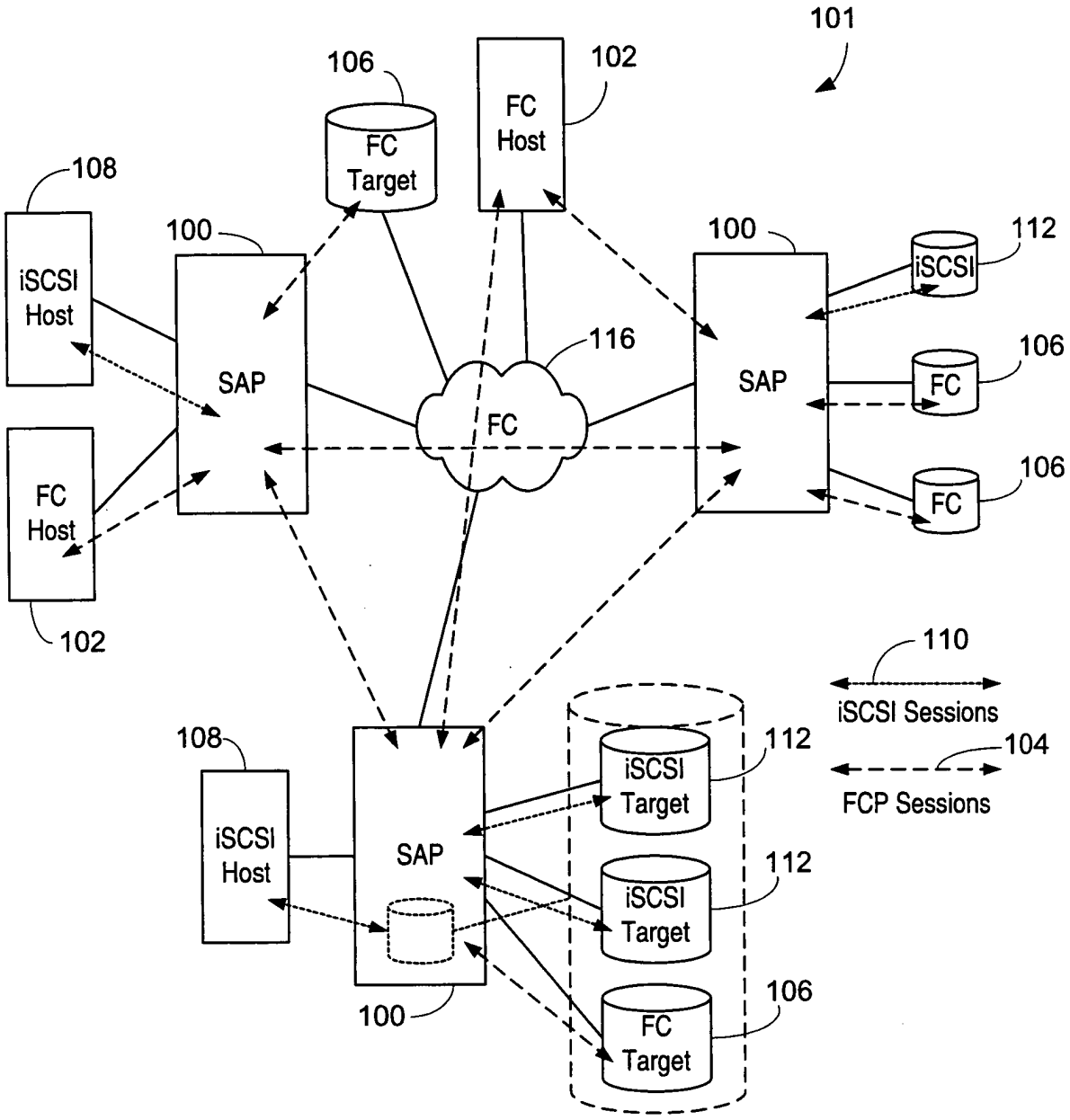
101
106
FC Target
102
FC Host
108
iSCSI Host
100
SAP
116
FC
100
SAP
112
iSCSI
106
FC
106
FC
FC Host
102
110
iSCSI Sessions
104
FCP Sessions
108
iSCSI Host
SAP
100
112
iSCSI Target
112
iSCSI Target
106
FC Target

FIG. 1B

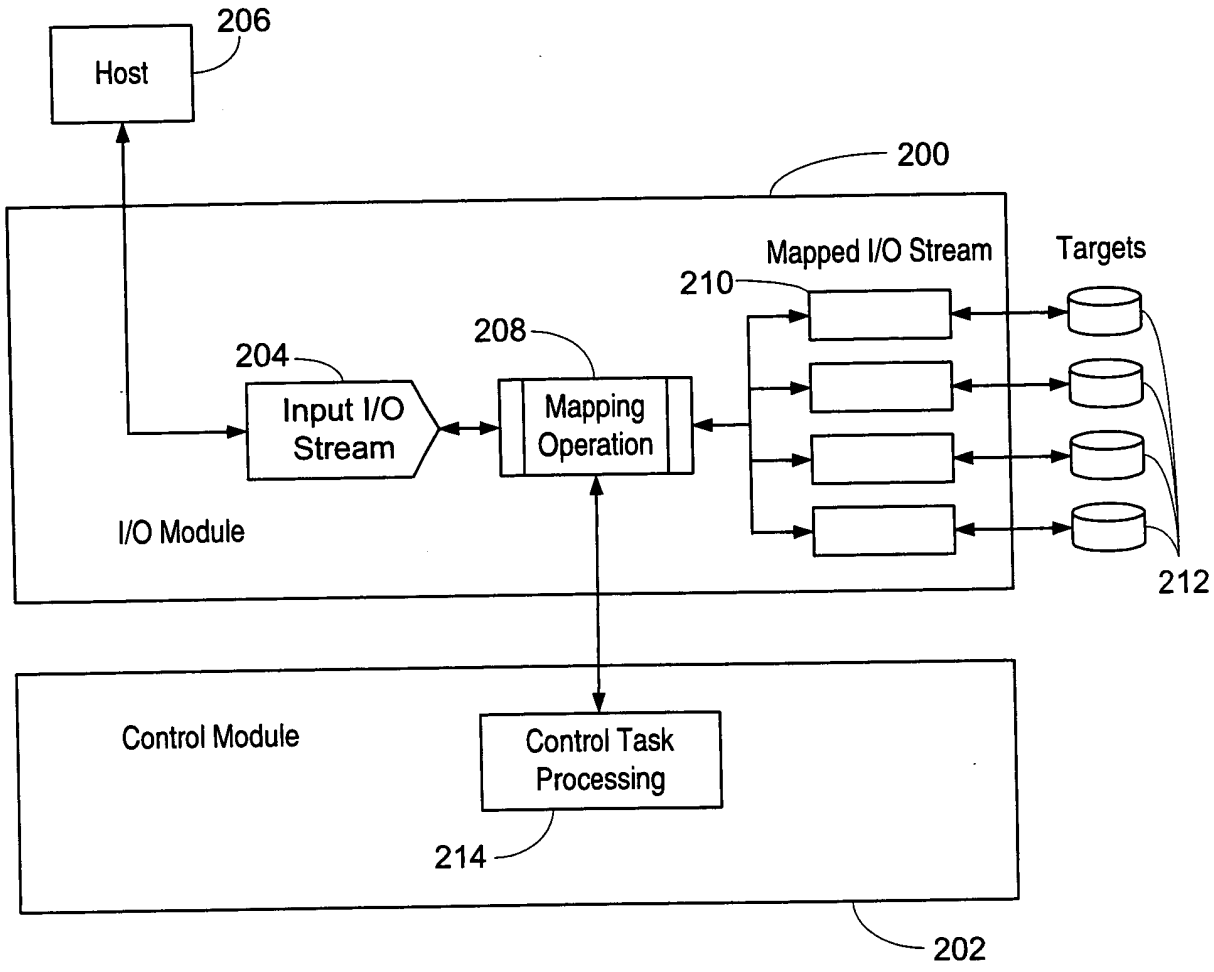
206
Host
200
Mapped I/O Stream
Targets
210
208
204
Input I/O Stream
Mapping Operation
I/O Module
212
Control Module
Control Task Processing
214
202

FIG. 2

Software	Industry APIs Topology & Discovery Routines Network Management	Fibre Channel Connectivity Processor IP Connectivity Processor Management Processor . . .
Firmware	I/O Processor Port Processors	Custom Application Segments Virtualization Engine
Silicon	Crossbar Switch	Custom Application Segments

FIG. 3

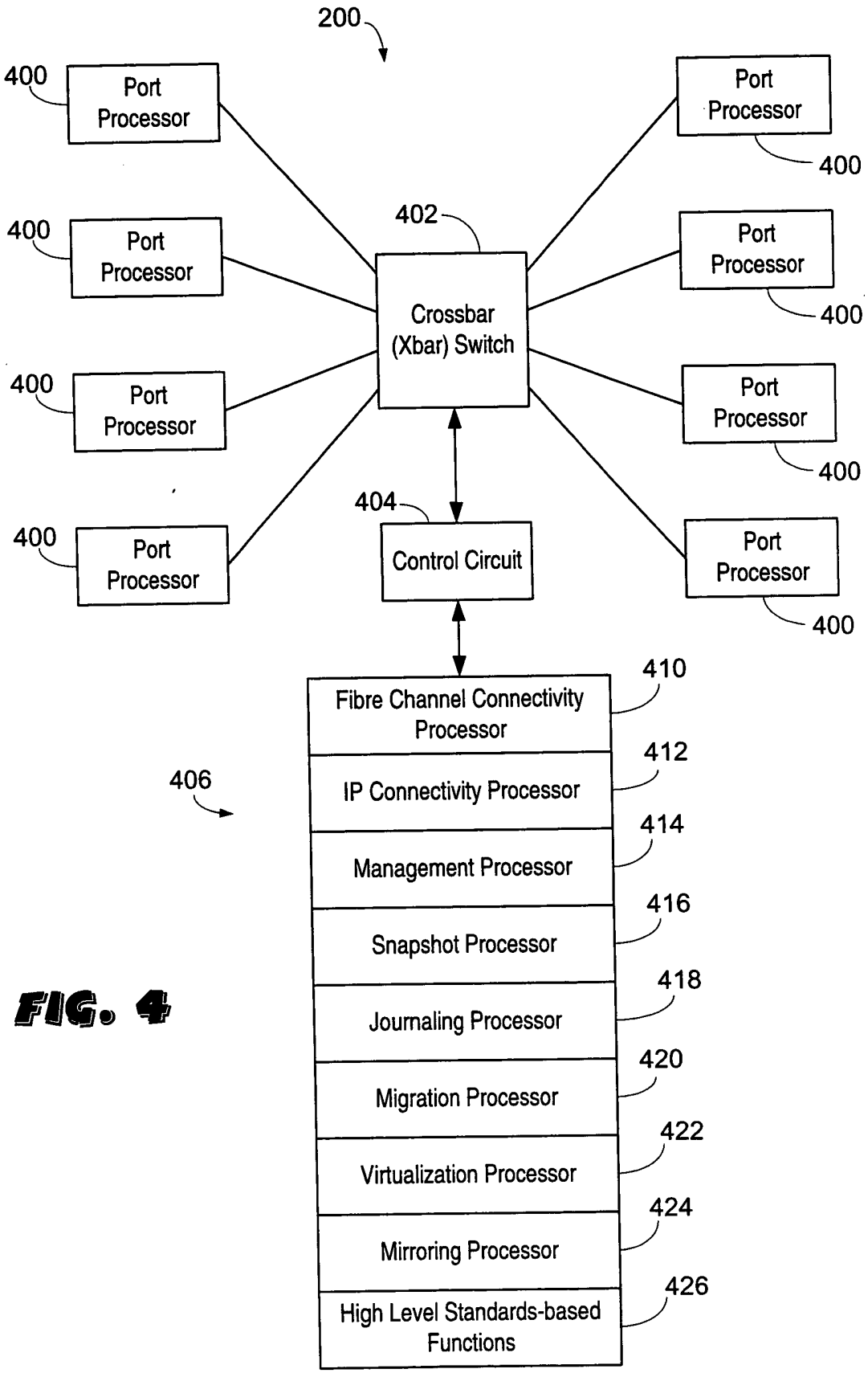
200
400
Port Processor
400
Port Processor
400
Port Processor
400
Port Processor
402
Crossbar (Xbar) Switch
400
Port Processor
400
Port Processor
400
Port Processor
400
Port Processor
404
Control Circuit
406
410
Fibre Channel Connectivity Processor
412
IP Connectivity Processor
414
Management Processor
416
Snapshot Processor
418
Journaling Processor
420
Migration Processor
422
Virtualization Processor
424
Mirroring Processor
426
High Level Standards-based Functions

FIG. 4

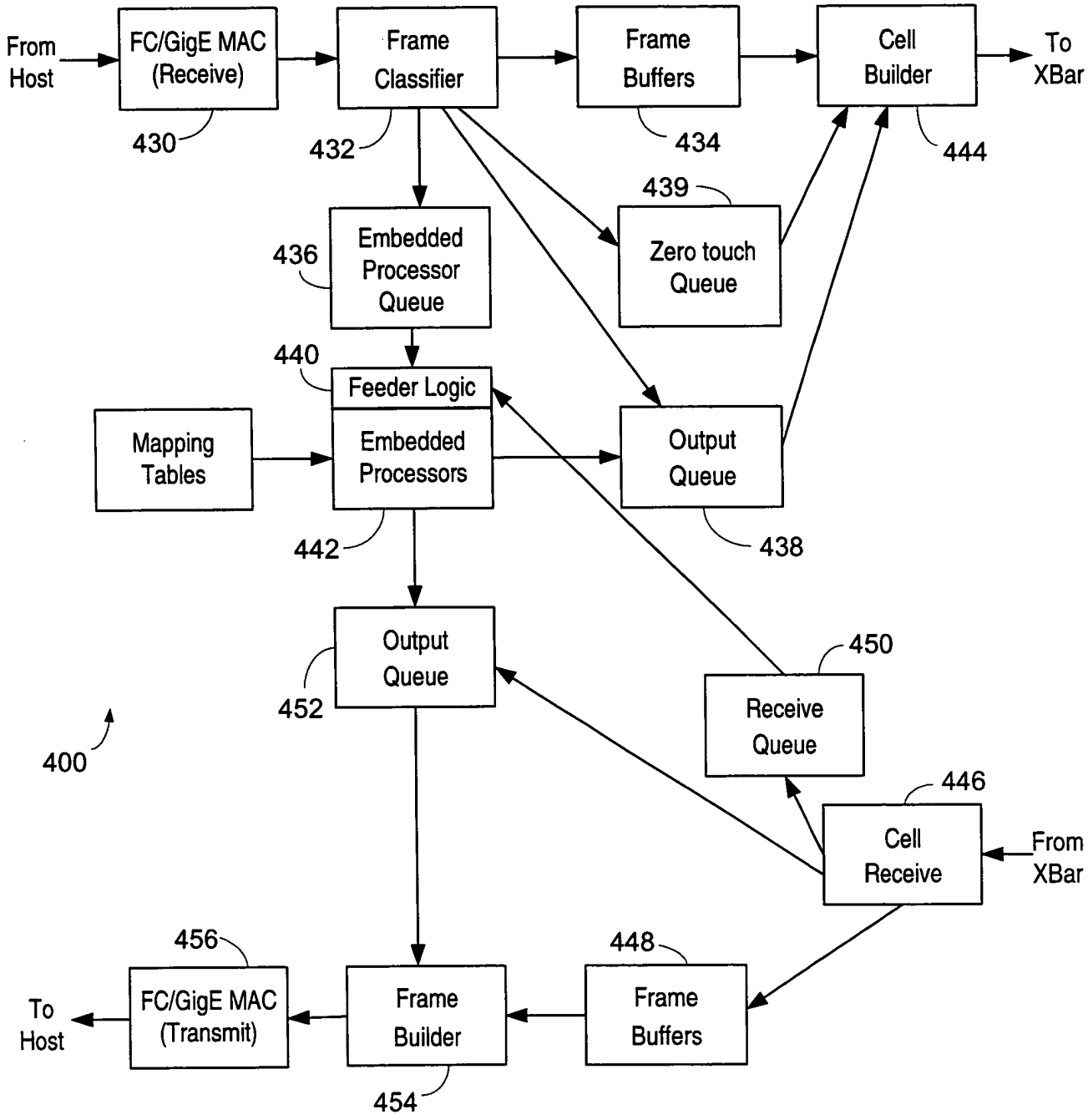
From Host
FC/GigE MAC (Receive)
Frame Classifier
Frame Buffers
Cell Builder
To XBar
430
432
434
444
439
Zero touch Queue
436
Embedded Processor Queue
440
Feeder Logic
Mapping Tables
Embedded Processors
Output Queue
442
438
Output Queue
452
450
Receive Queue
400
446
Cell Receive
From XBar
456
448
To Host
FC/GigE MAC (Transmit)
Frame Builder
Frame Buffers
454

FIG. 5

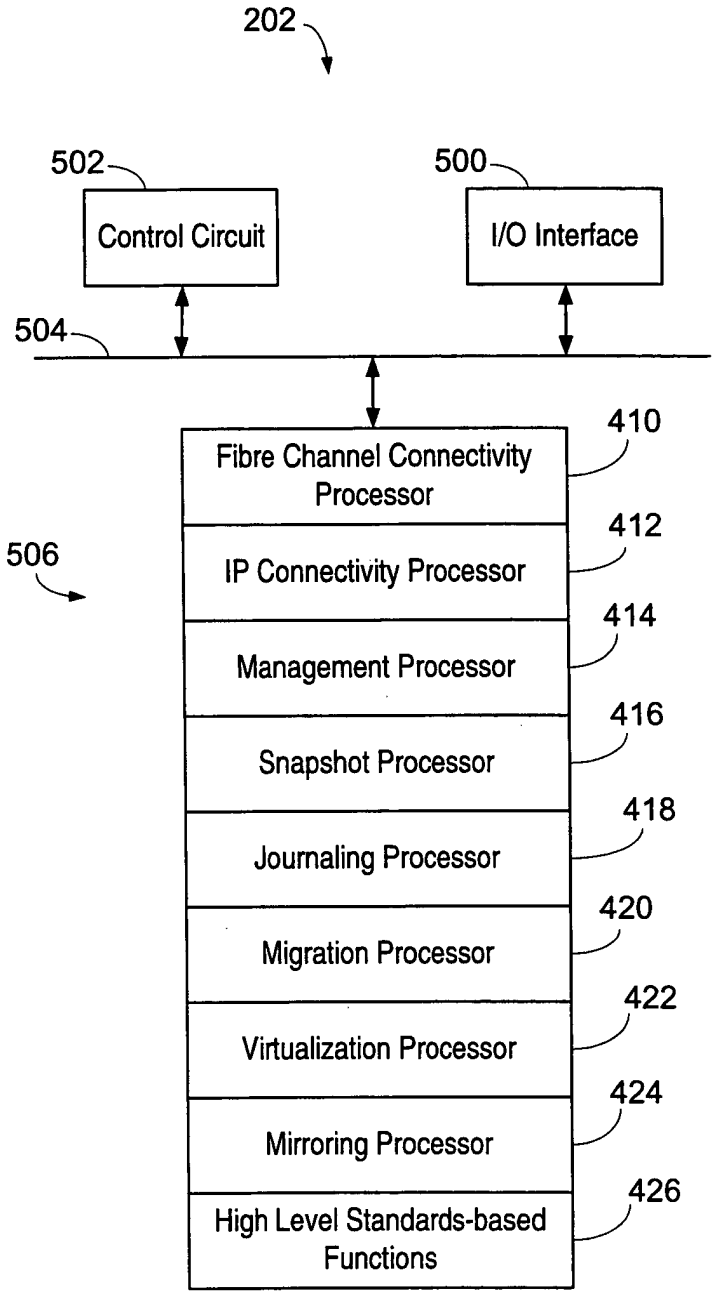
202
502
Control Circuit
500
I/O Interface
504
506
410
Fibre Channel Connectivity Processor
412
IP Connectivity Processor
414
Management Processor
416
Snapshot Processor
418
Journaling Processor
420
Migration Processor
422
Virtualization Processor
424
Mirroring Processor
426
High Level Standards-based Functions

FIG. 6

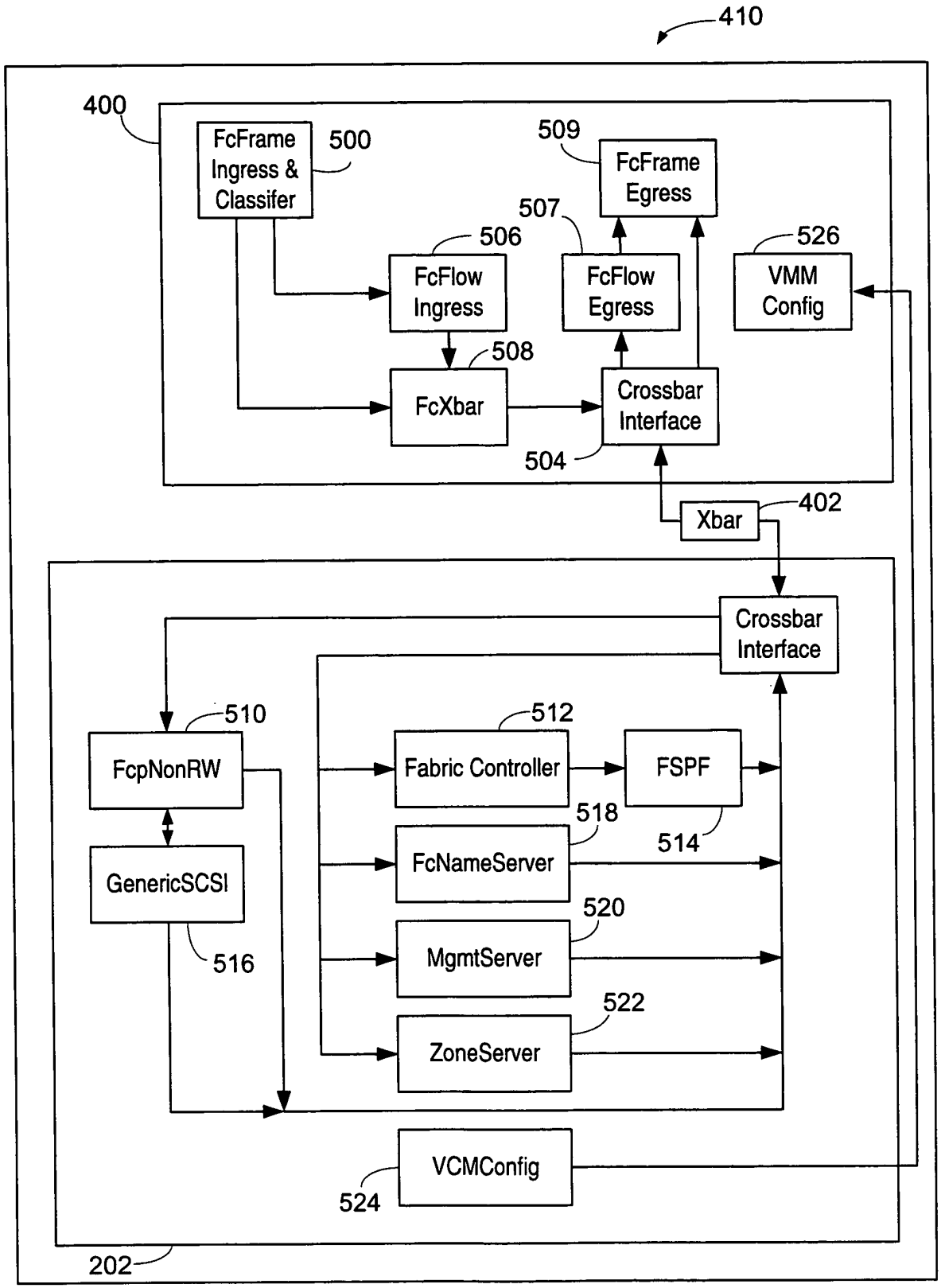
410
400
FcFrame Ingress & Classifer
500
509
FcFrame Egress
507
506
FcFlow Ingress
FcFlow Egress
526
VMM Config
508
FcXbar
Crossbar Interface
504
Xbar
402
Crossbar Interface
510
FcpNonRW
512
Fabric Controller
FSPF
518
514
FcNameServer
GenericSCSI
520
516
MgmtServer
522
ZoneServer
VCMConfig
524
202

FIG. 7

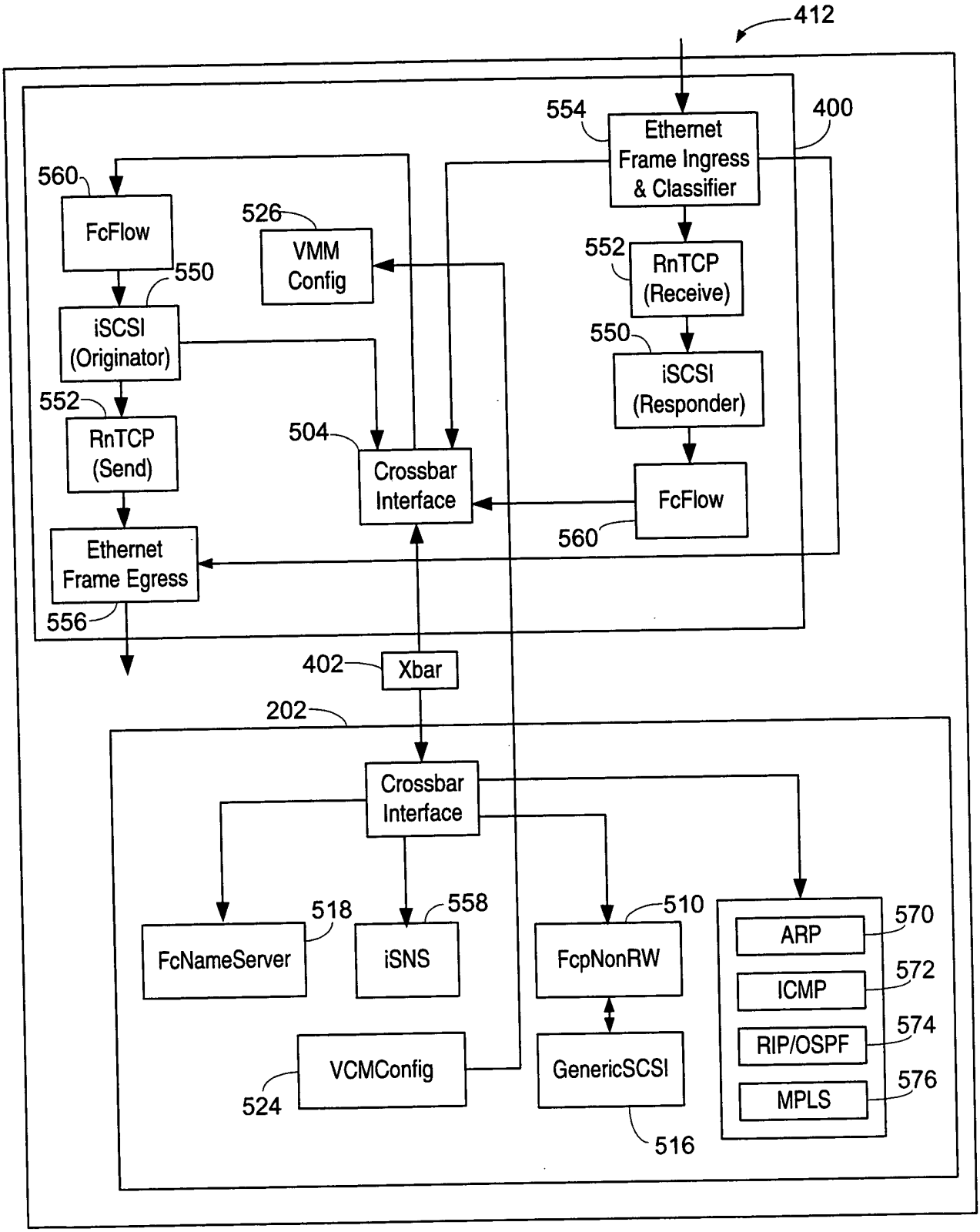
412
400
554
Ethernet
Frame Ingress
& Classifier
560
FcFlow
526
VMM
Config
552
RnTCP
(Receive)
550
iSCSI
(Originator)
550
iSCSI
(Responder)
552
RnTCP
(Send)
504
Crossbar
Interface
FcFlow
560
Ethernet
Frame Egress
556
402
Xbar
202
Crossbar
Interface
518
FcNameServer
558
iSNS
510
FcpNonRW
570
ARP
572
ICMP
574
RIP/OSPF
576
MPLS
VCMConfig
524
GenericSCSI
516

FIG. 8

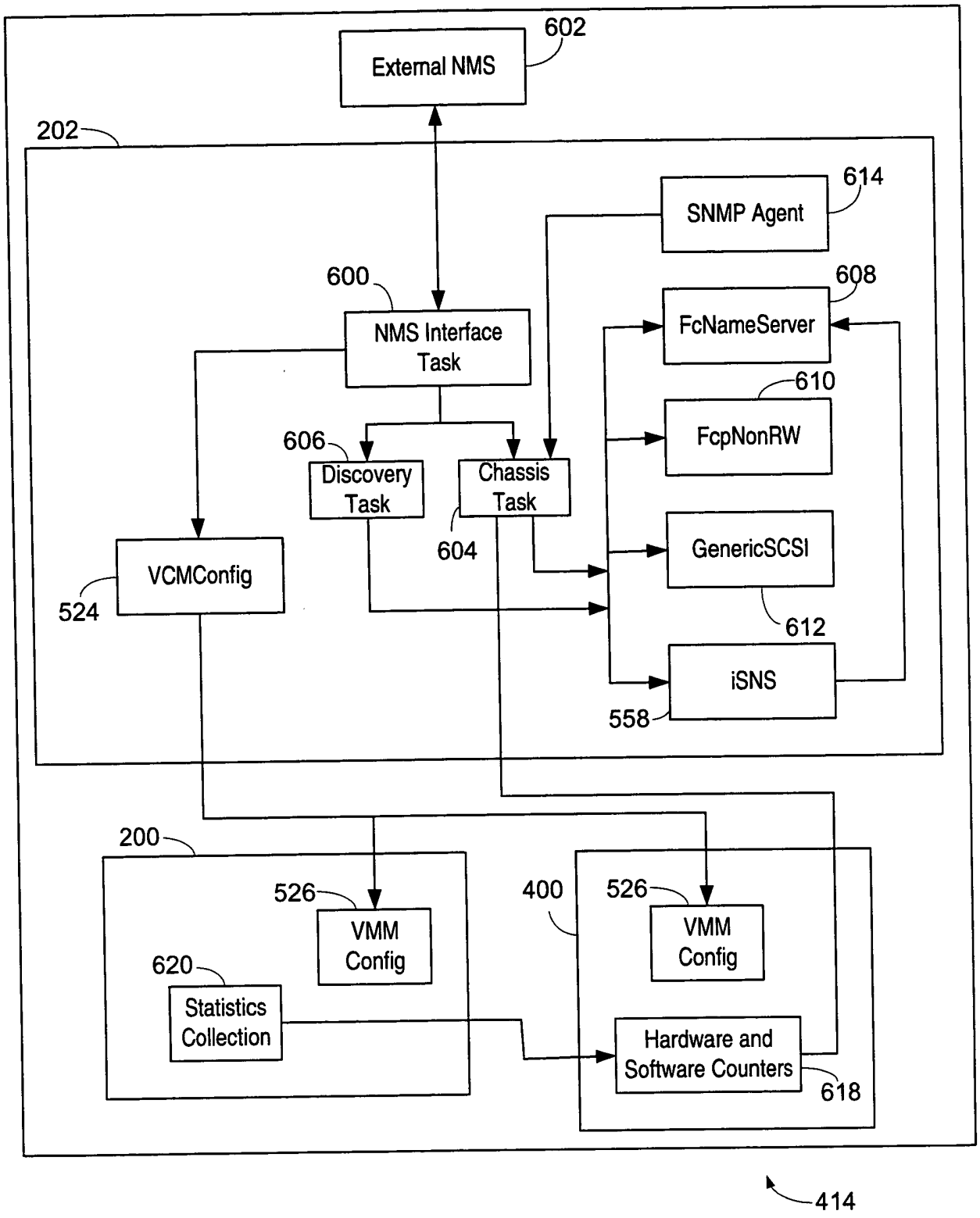
External NMS
602
202
SNMP Agent
614
600
608
NMS Interface Task
FcNameServer
610
FcpNonRW
606
Discovery Task
Chassis Task
604
GenericSCSI
VCMConfig
524
612
iSNS
558
200
526
VMM Config
400
526
VMM Config
620
Statistics Collection
Hardware and Software Counters
618
414

FIG. 9

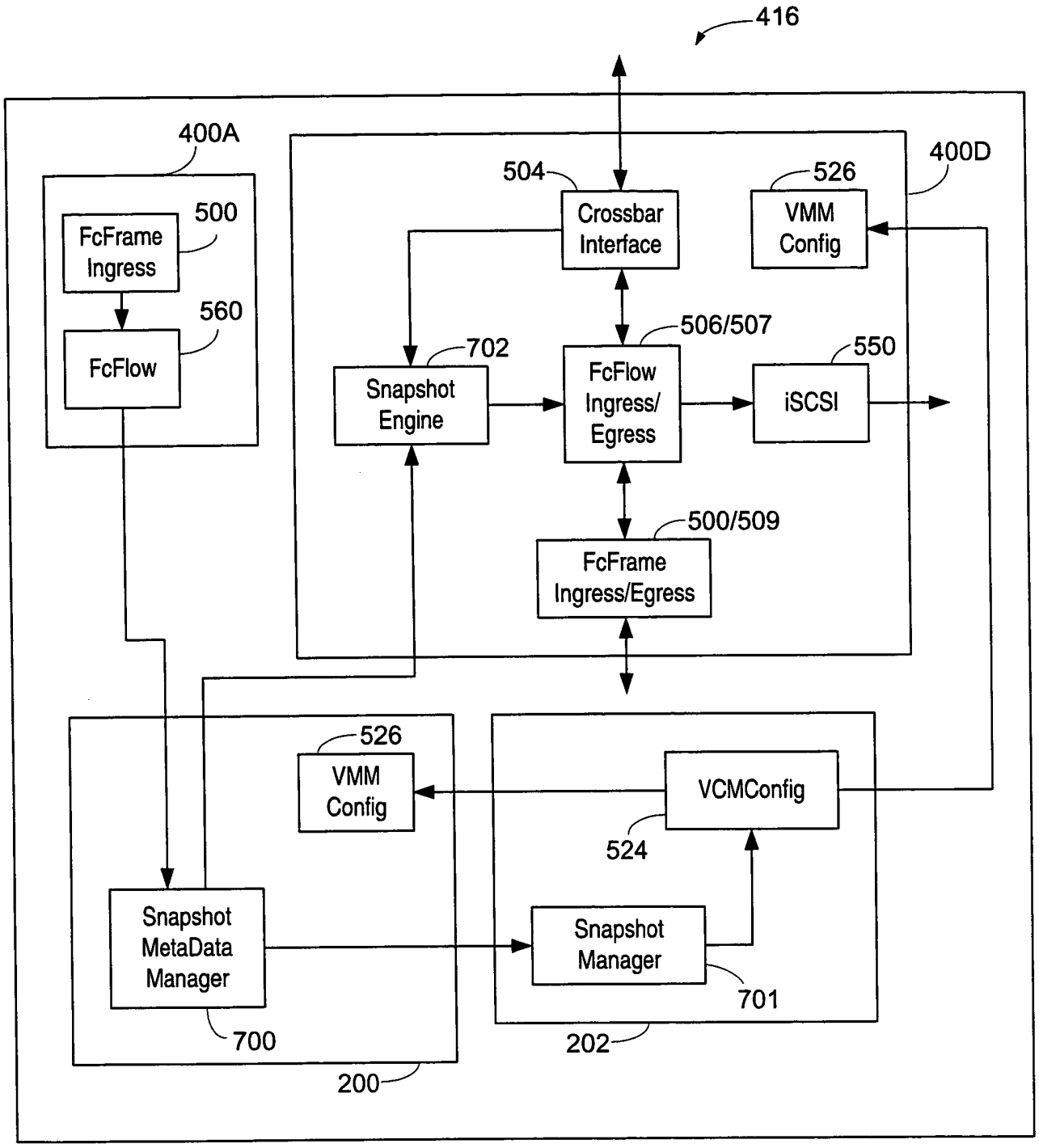
416
400A
400D
FcFrame Ingress
500
FcFlow
560
504
Crossbar Interface
526
VMM Config
506/507
702
Snapshot Engine
FcFlow Ingress/ Egress
550
iSCSI
500/509
FcFrame Ingress/Egress
526
VMM Config
VCMConfig
524
Snapshot MetaData Manager
Snapshot Manager
701
700
202
200

FIG. 10

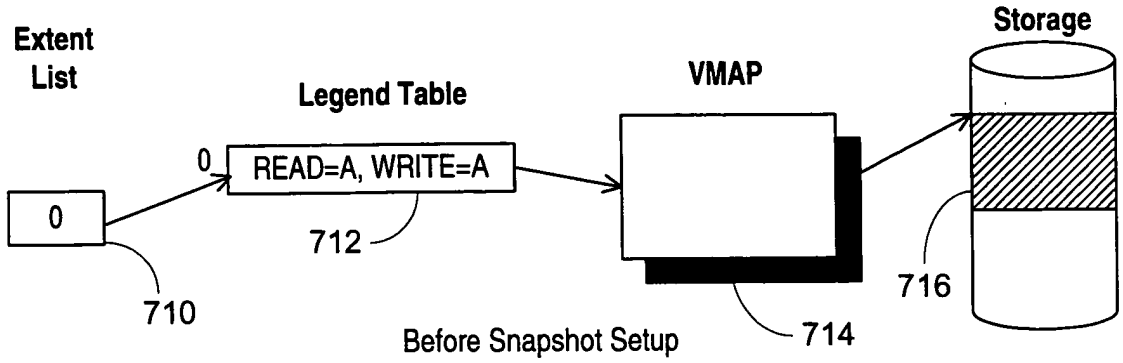
Extent
List
Legend Table
VMAP
Storage
0
READ=A, WRITE=A
0
712
710
716
714
Before Snapshot Setup

FIG. 11

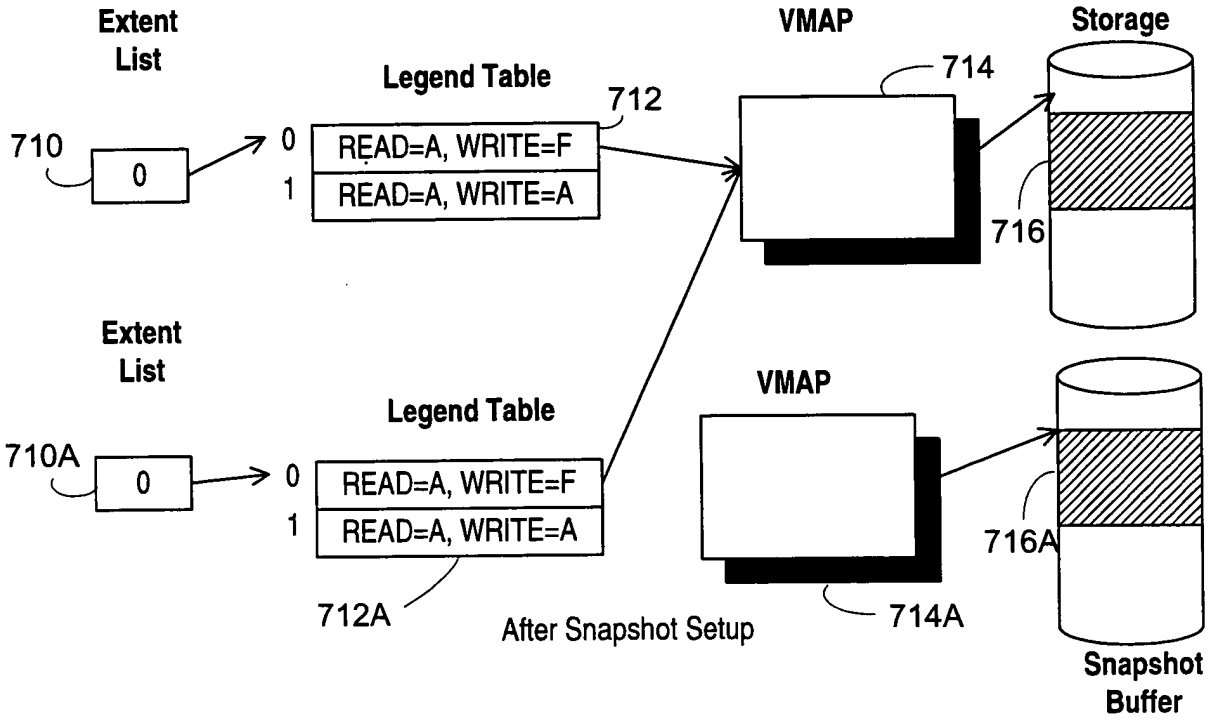
Extent
List
Legend Table
VMAP
Storage
714
712
710
0
0
READ=A, WRITE=F
1
READ=A, WRITE=A
716
Extent
List
VMAP
Legend Table
710A
0
0
READ=A, WRITE=F
1
READ=A, WRITE=A
716A
712A
After Snapshot Setup
714A
Snapshot
Buffer

FIG. 12

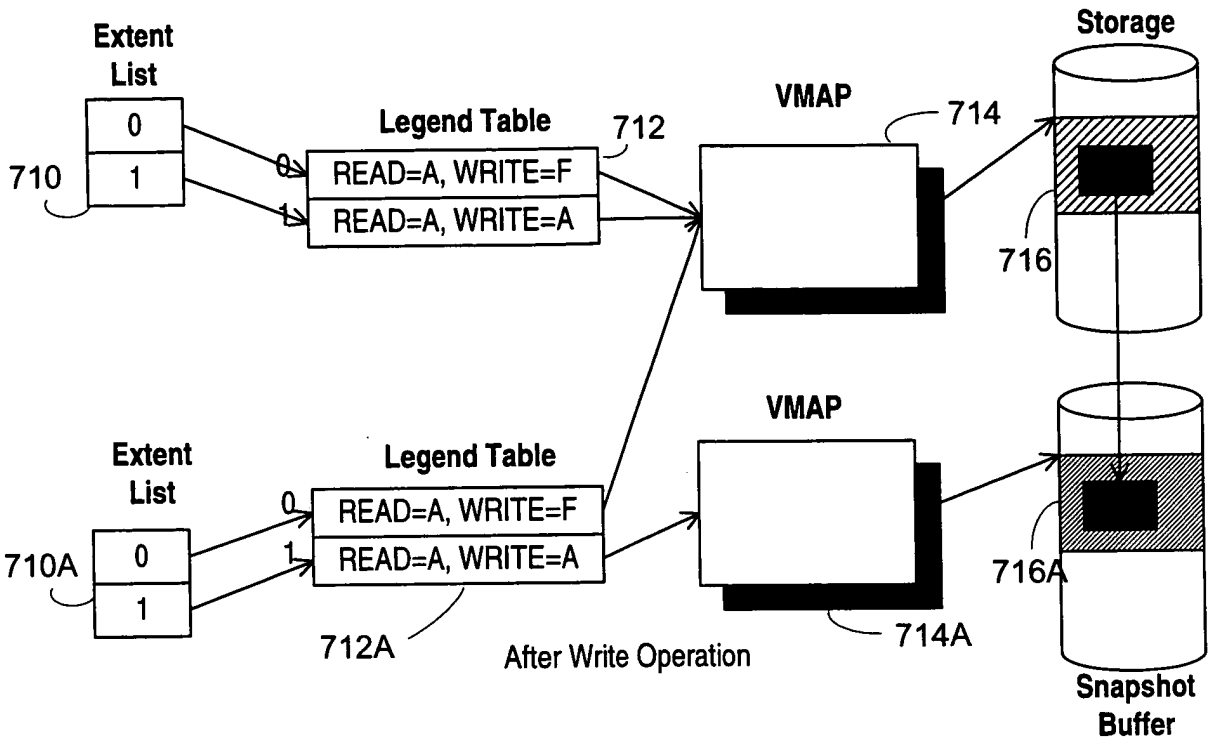
Extent List
0
1
710
Legend Table
0
1
READ=A, WRITE=F
READ=A, WRITE=A
712
VMAP
714
Storage
716
Extent List
710A
0
1
Legend Table
0
1
READ=A, WRITE=F
READ=A, WRITE=A
712A
VMAP
714A
716A
After Write Operation
Snapshot Buffer

FIG. 13

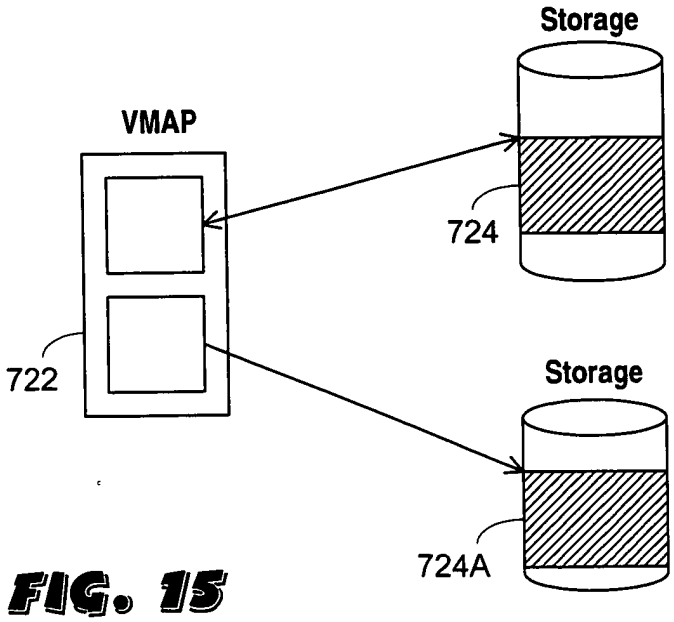
Storage
VMAP
724
722
Storage
724A

FIG. 15

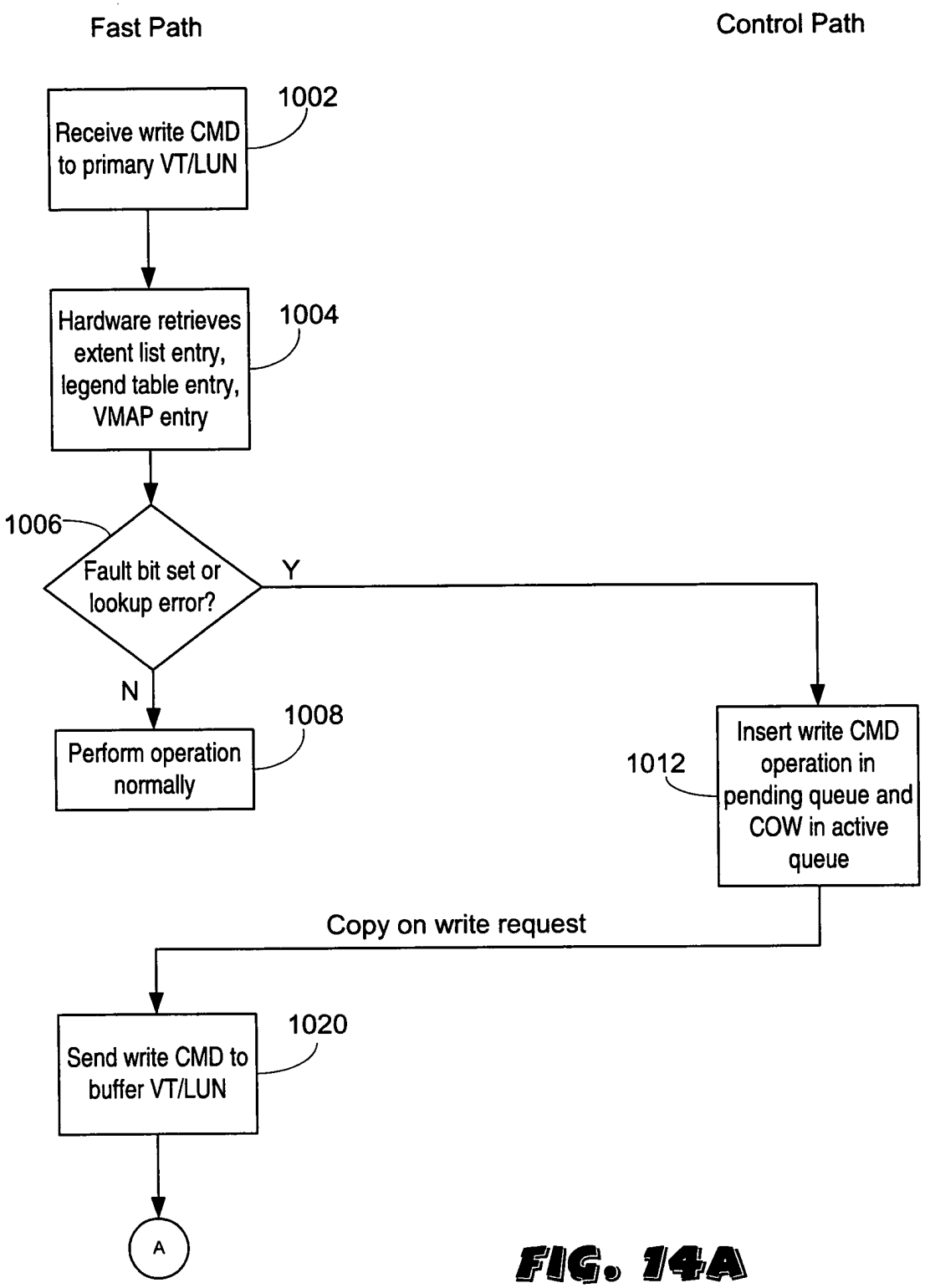
Fast Path
Control Path
Receive write CMD to primary VT/LUN
1002
Hardware retrieves extent list entry, legend table entry, VMAP entry
1004
1006
Fault bit set or lookup error?
Y
N
Perform operation normally
1008
Insert write CMD operation in pending queue and COW in active queue
1012
Copy on write request
Send write CMD to buffer VT/LUN
1020
A

FIG. 14A

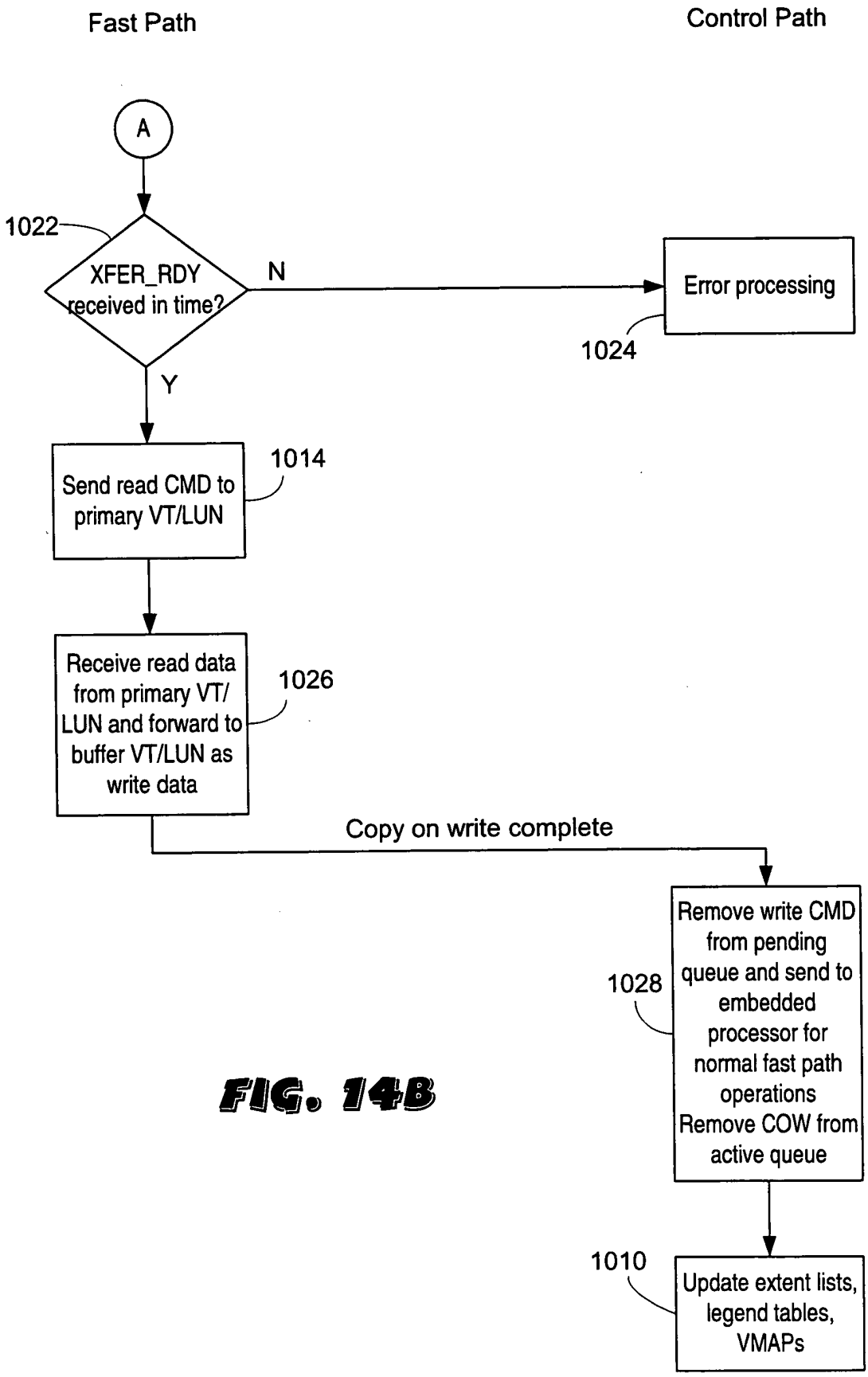
Fast Path
Control Path
A
1022
XFER_RDY received in time?
N
Error processing
1024
Y
Send read CMD to primary VT/LUN
1014
Receive read data from primary VT/ LUN and forward to buffer VT/LUN as write data
1026
Copy on write complete
Remove write CMD from pending queue and send to embedded processor for normal fast path operations Remove COW from active queue
1028
1010
Update extent lists, legend tables, VMAPs

FIG. 14B

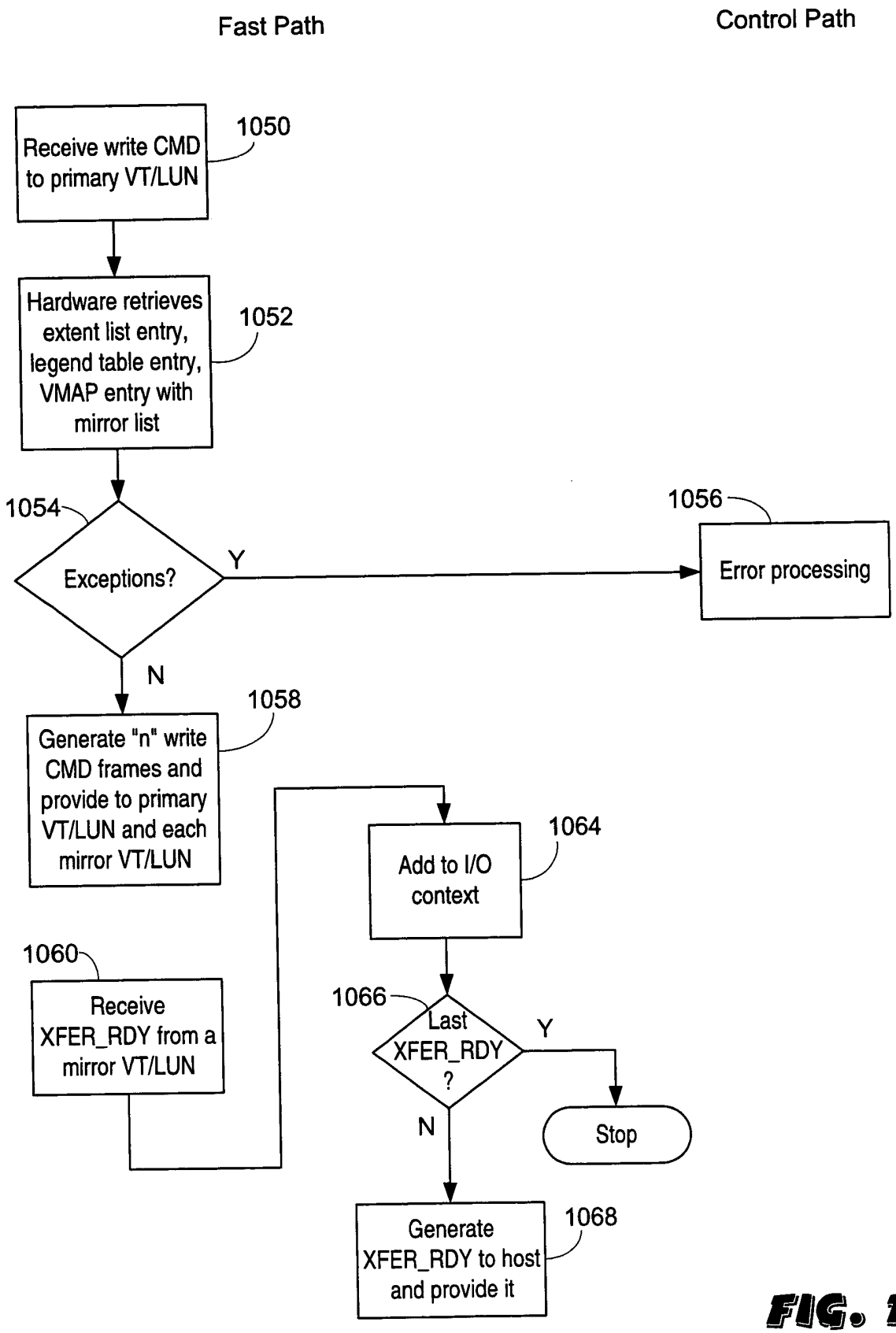
Fast Path
Control Path
Receive write CMD to primary VT/LUN
1050
Hardware retrieves extent list entry, legend table entry, VMAP entry with mirror list
1052
1054
Exceptions?
Y
1056
Error processing
N
1058
Generate "n" write CMD frames and provide to primary VT/LUN and each mirror VT/LUN
1060
Receive XFER_RDY from a mirror VT/LUN
1064
Add to I/O context
1066
Last XFER_RDY ?
Y
N
Stop
Generate XFER_RDY to host and provide it
1068

FIG. 16A

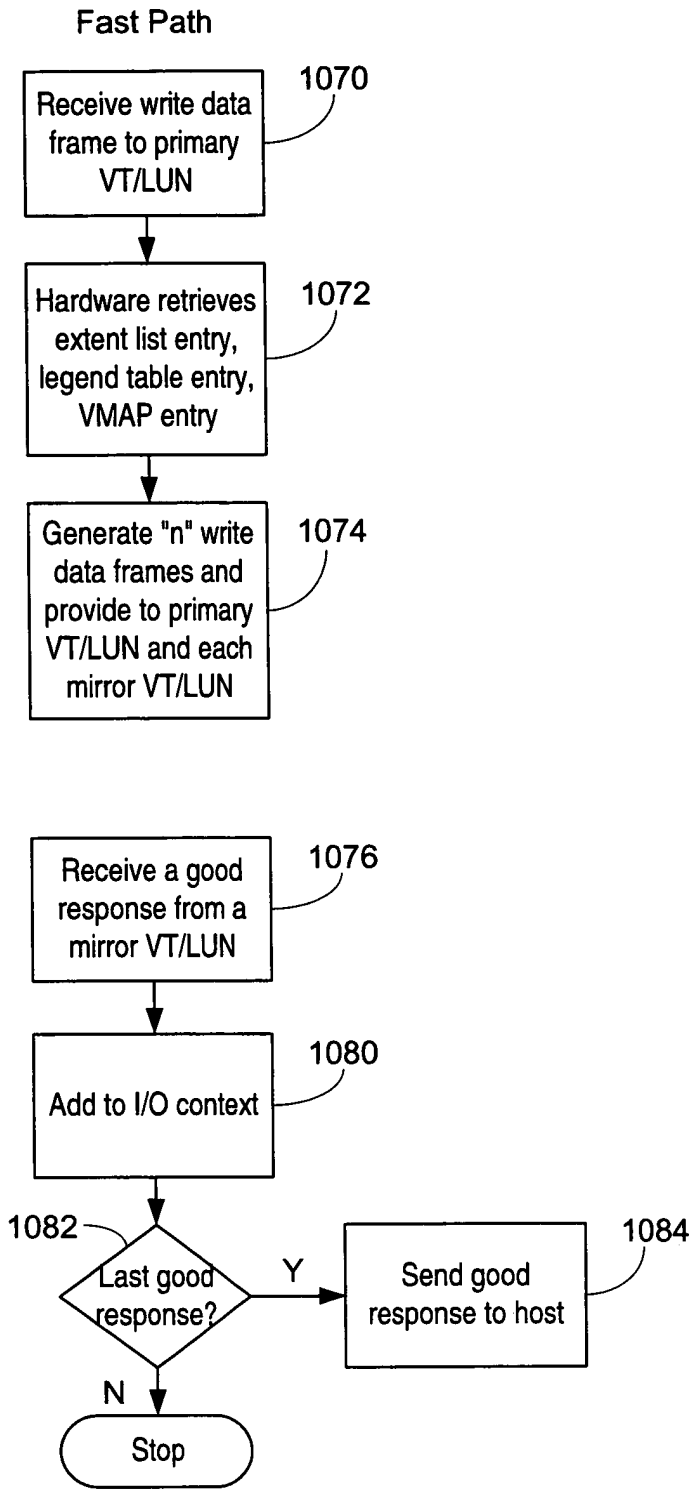
Fast Path
Receive write data frame to primary VT/LUN
1070
Hardware retrieves extent list entry, legend table entry, VMAP entry
1072
Generate "n" write data frames and provide to primary VT/LUN and each mirror VT/LUN
1074
Receive a good response from a mirror VT/LUN
1076
Add to I/O context
1080
1082
Last good response?
Y
Send good response to host
1084
N
Stop

FIG. 16B

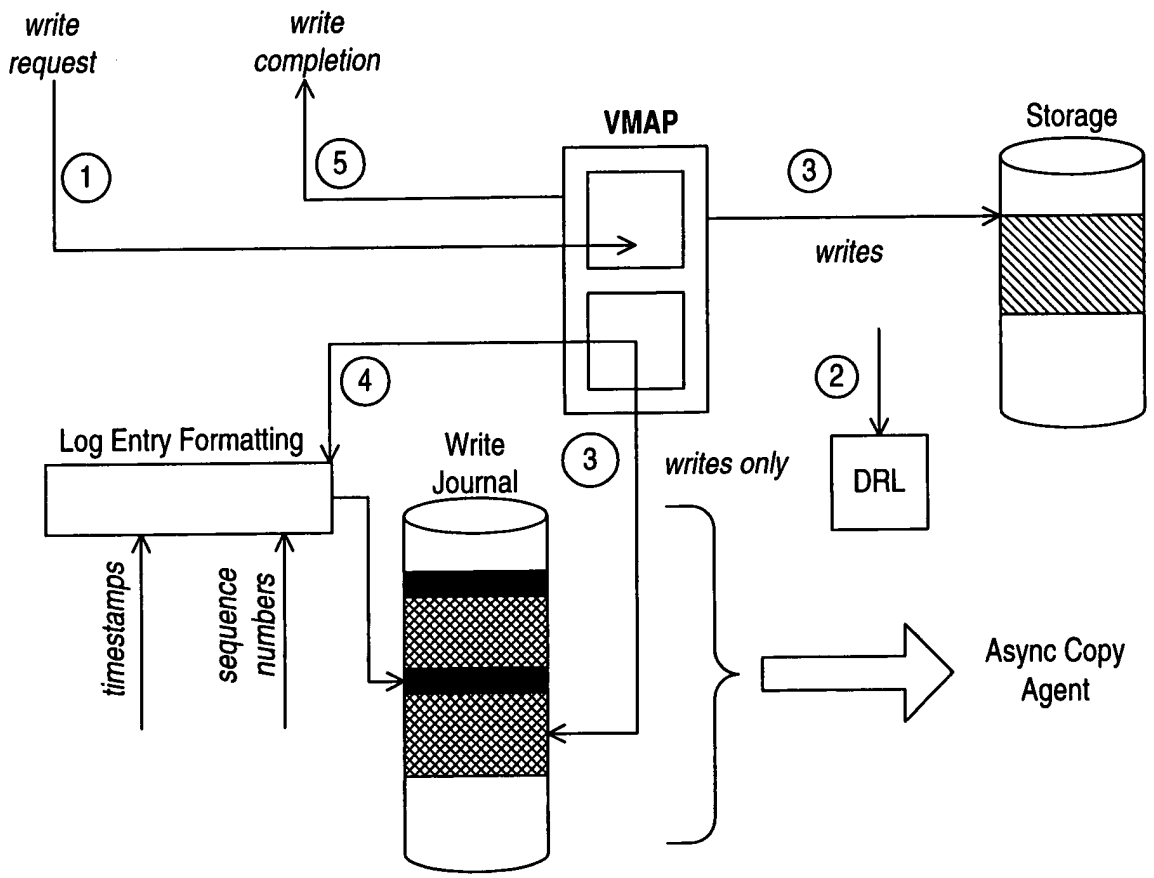
write
request
write
completion
VMAP
Storage
1
5
3
writes
4
2
Log Entry Formatting
Write
Journal
3
writes only
DRL
timestamps
sequence
numbers
Async Copy
Agent

FIG. 17

Fast Path

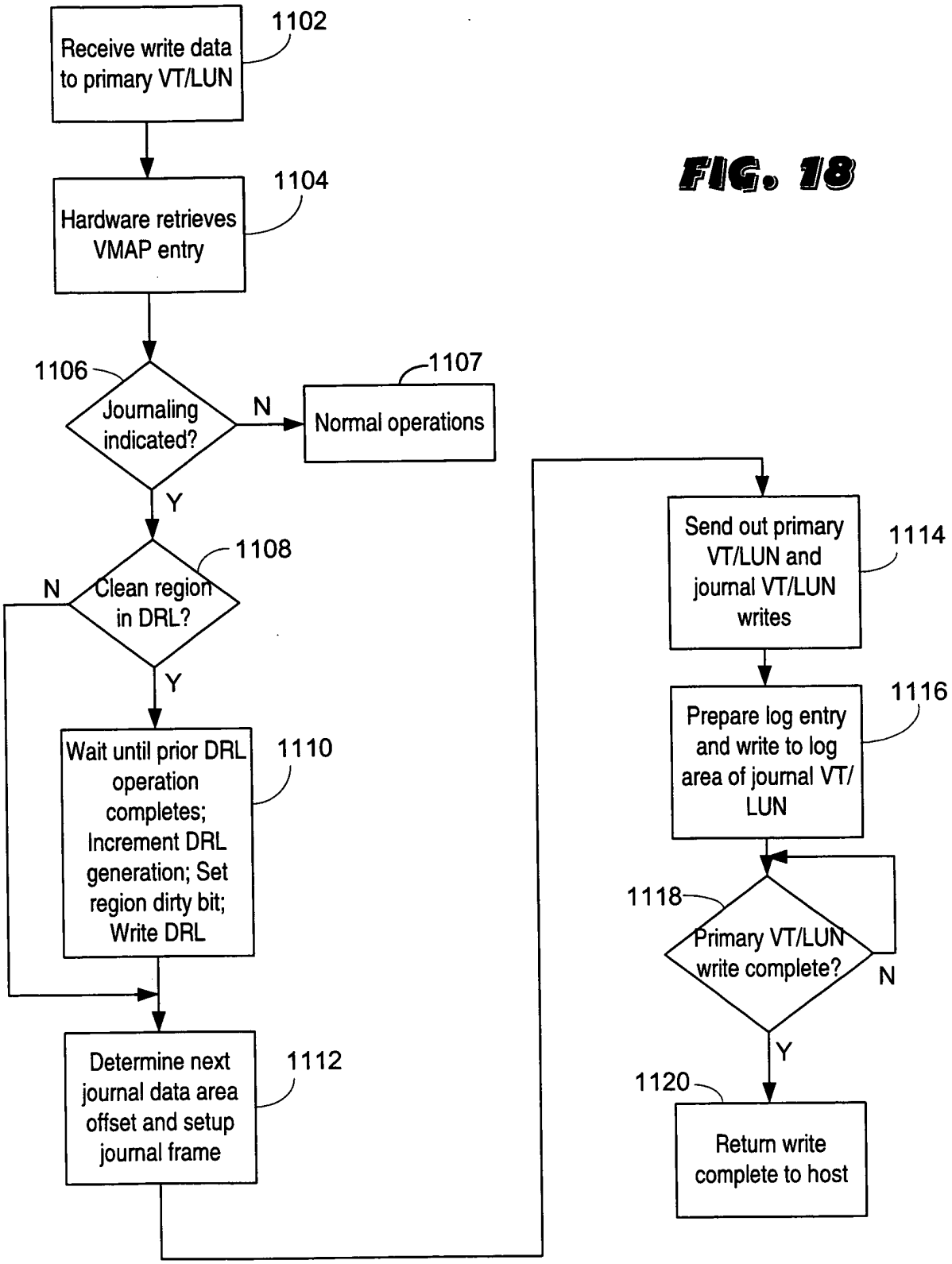

FIG. 18

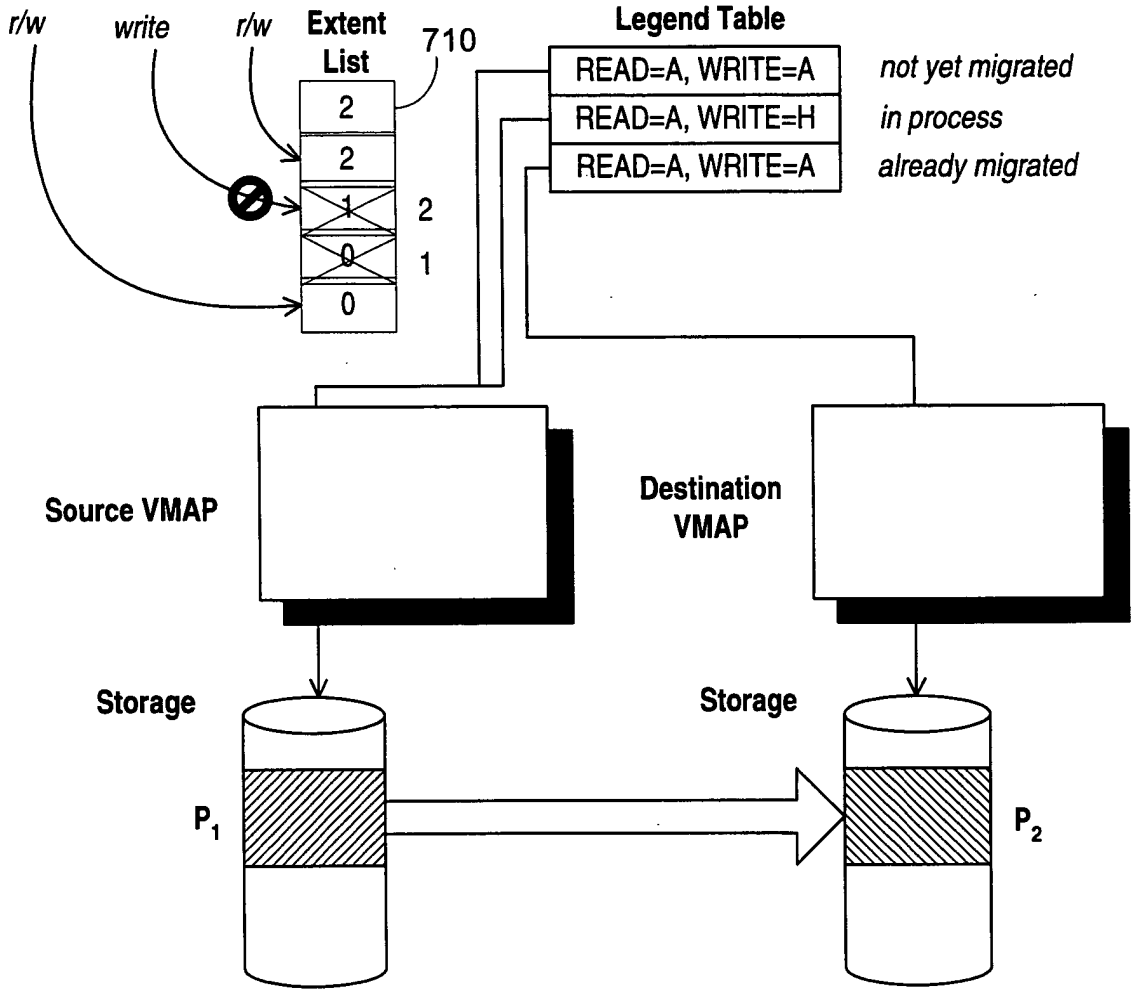
r/w
write
r/w
Extent List
710
Legend Table
READ=A, WRITE=A
READ=A, WRITE=H
READ=A, WRITE=A
not yet migrated
in process
already migrated
2
2
1
0
2
1
0
Source VMAP
Destination VMAP
Storage
Storage
P1
P2

FIG. 19

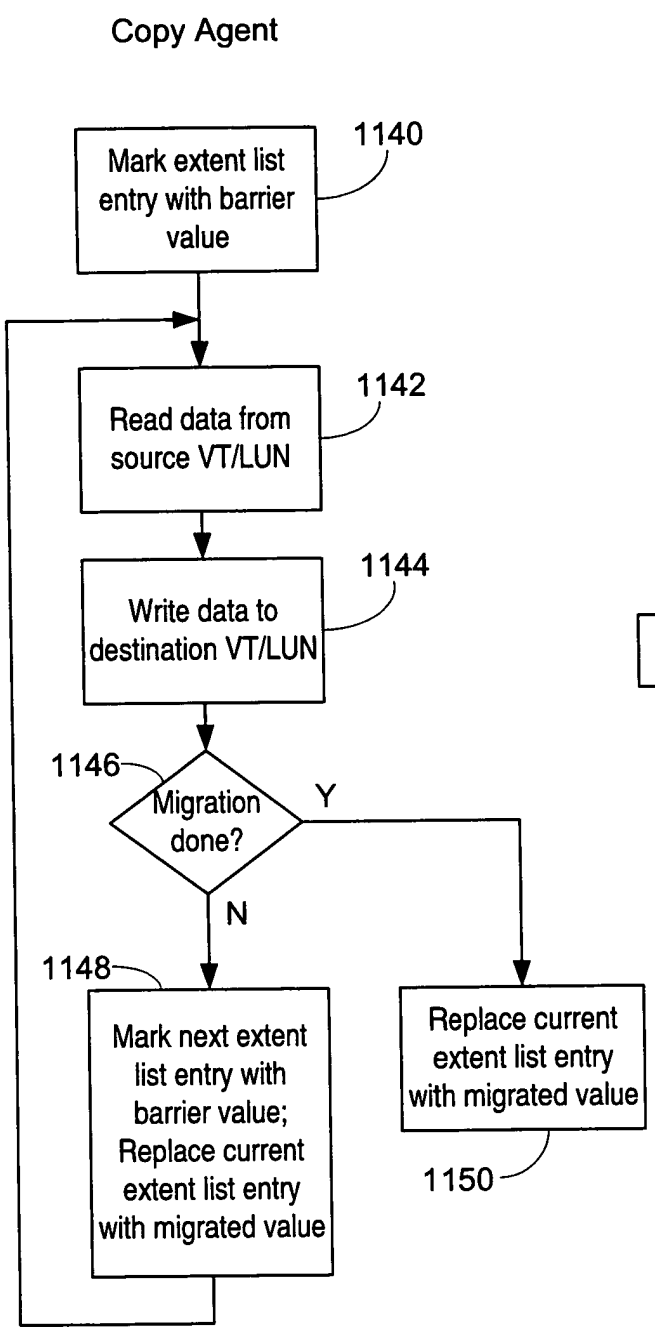

FIG. 20A

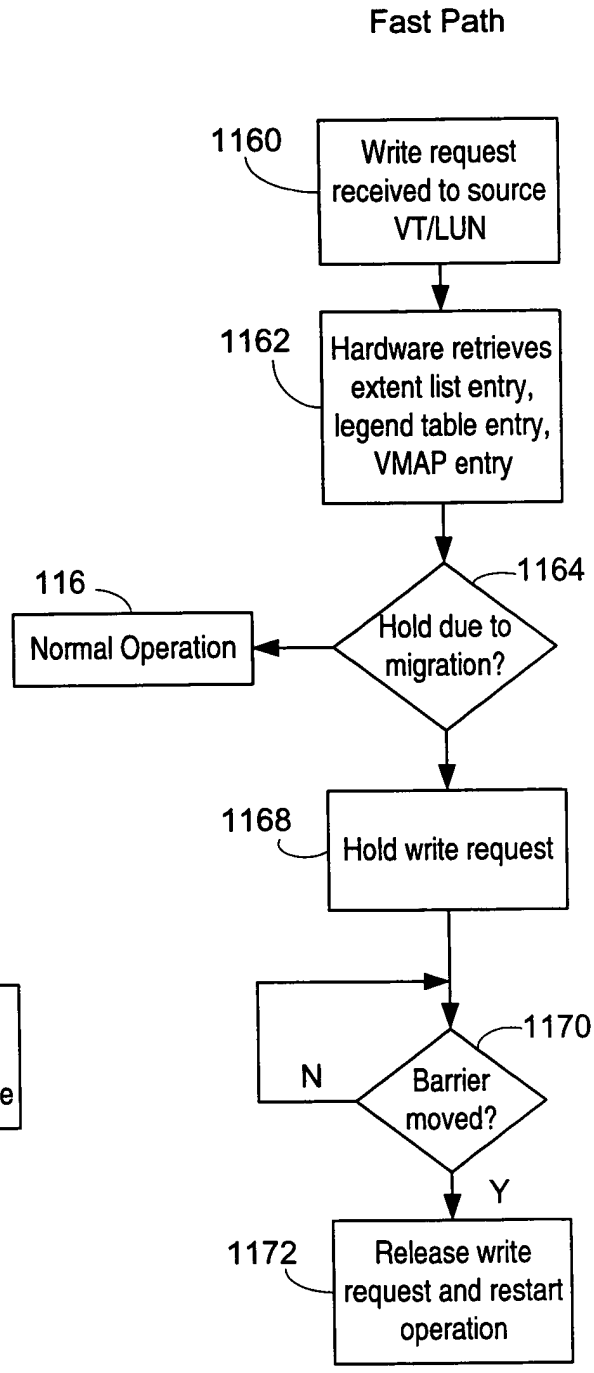

FIG. 20B

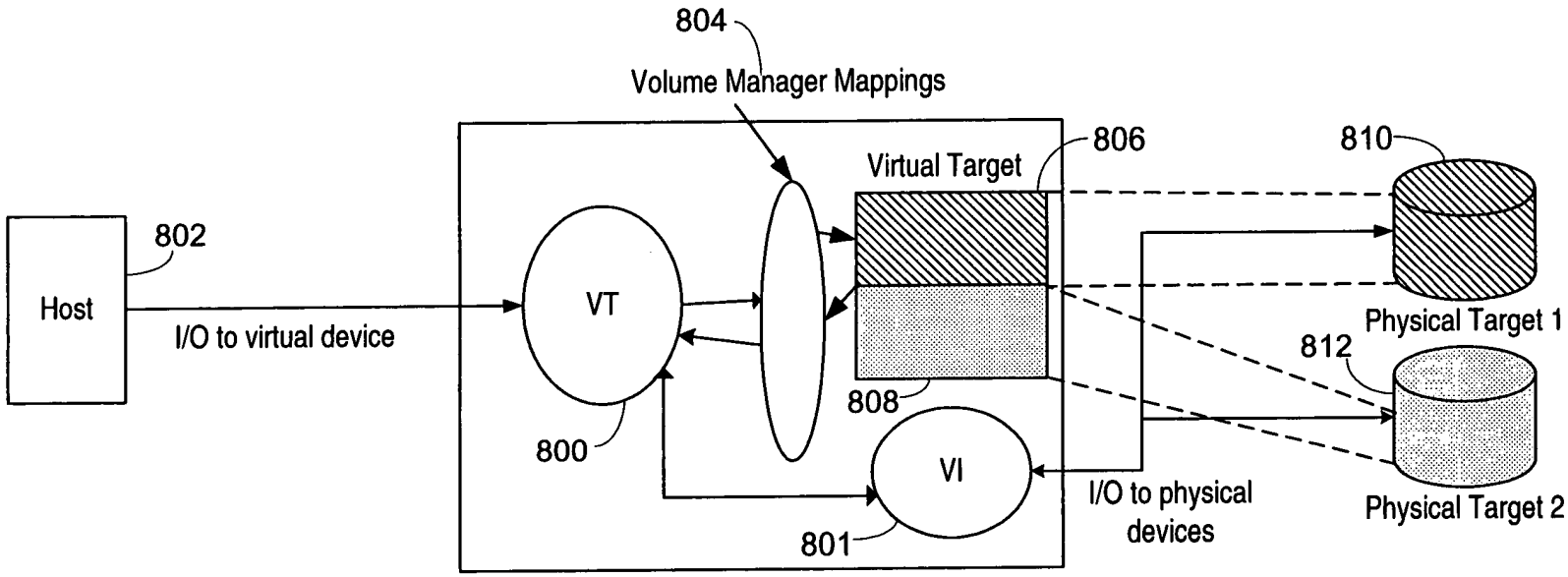
804
Volume Manager Mappings
806
Virtual Target
810
802
Host
I/O to virtual device
VT
Physical Target 1
812
808
800
VI
I/O to physical
devices
Physical Target 2
801

FIG. 21

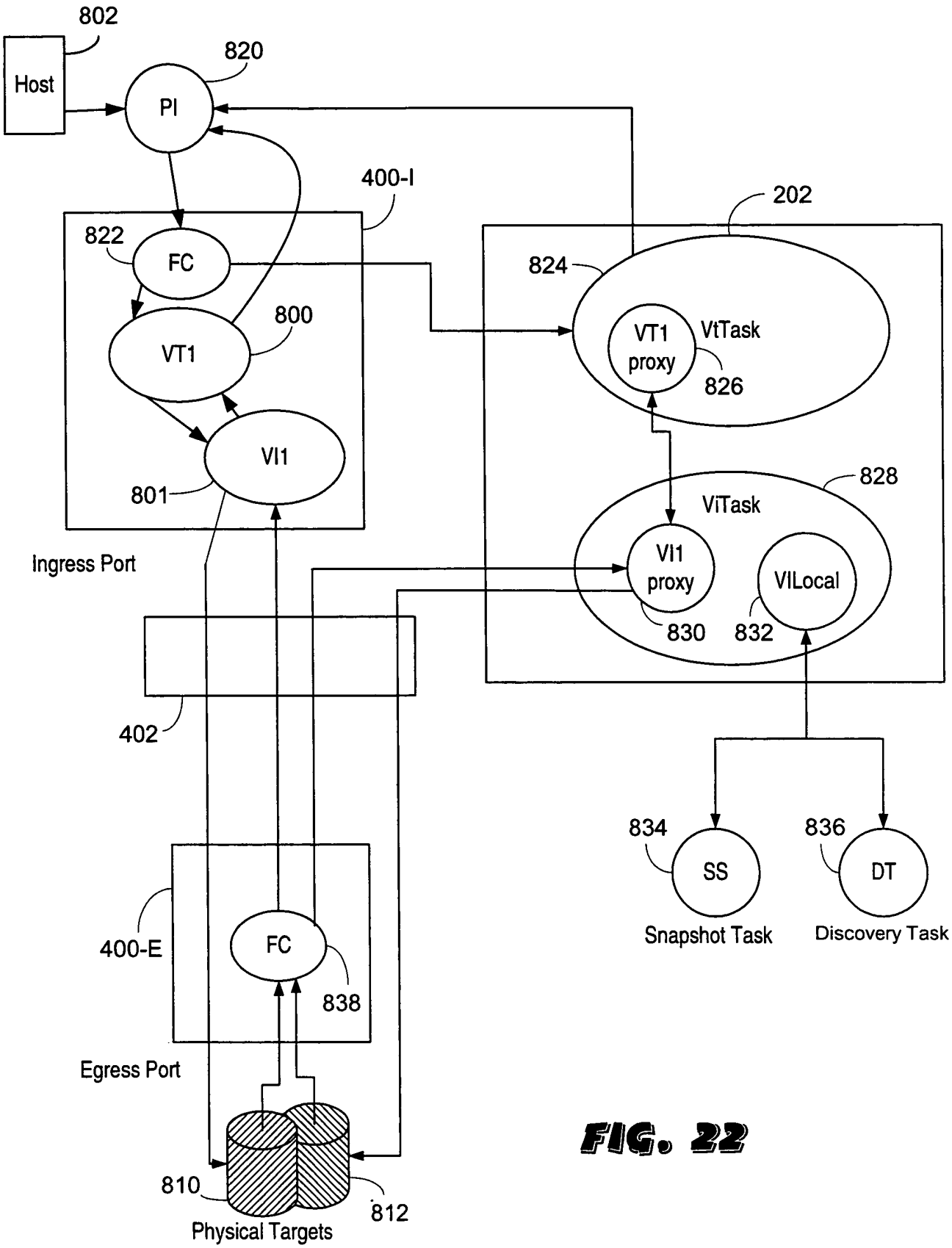
802
Host
820
PI
400-I
202
822
FC
824
800
VT1
VT1 proxy
VtTask
826
VI1
801
828
ViTask
Ingress Port
VI1 proxy
VILocal
830
832
402
834
SS
836
DT
Snapshot Task
Discovery Task
400-E
FC
838
Egress Port
810
812
Physical Targets

FIG. 22

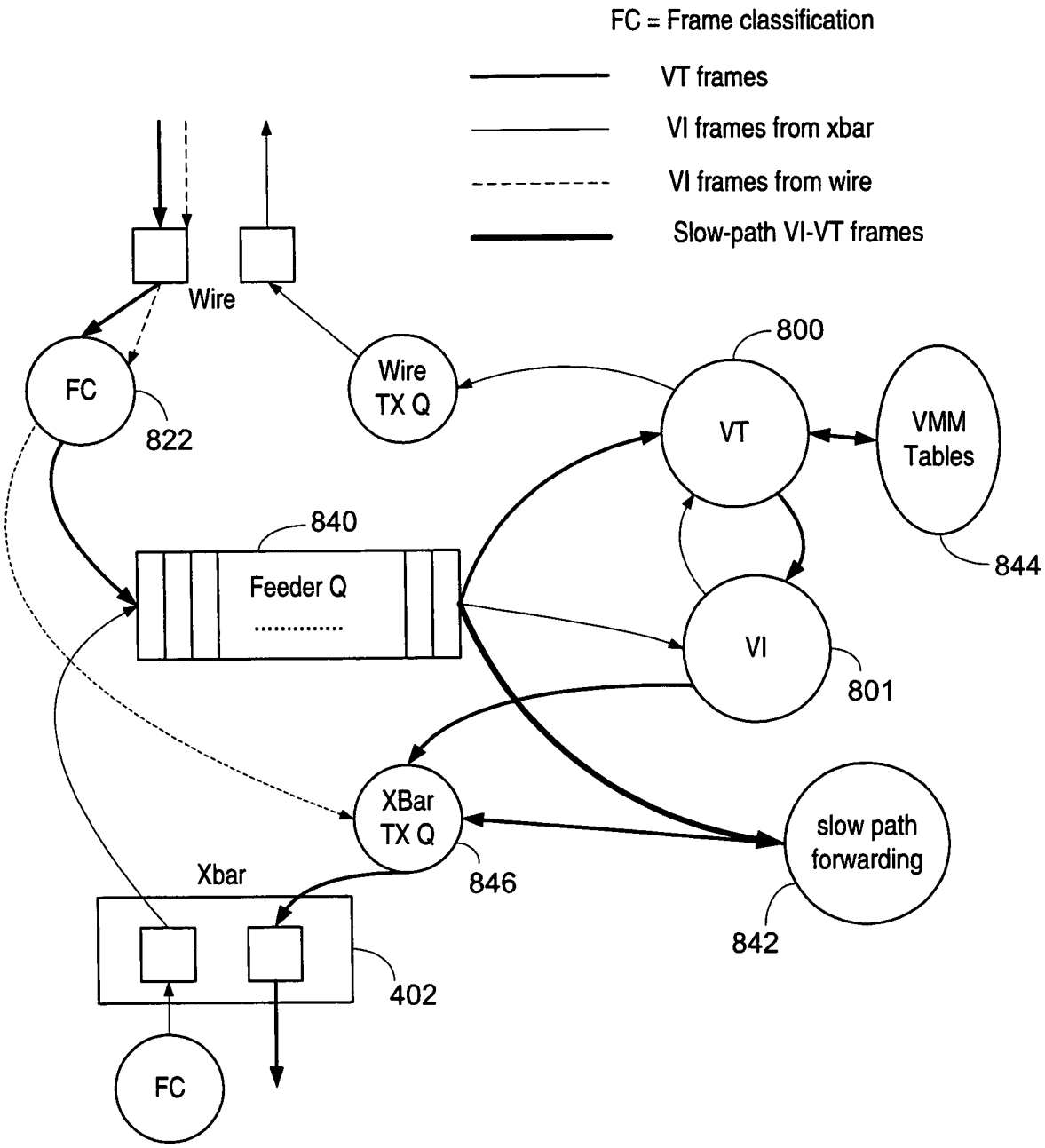
FC = Frame classification
VT frames
VI frames from xbar
VI frames from wire
Slow-path VI-VT frames
Wire
FC
822
Wire
TX Q
800
VT
VMM
Tables
844
840
Feeder Q
VI
801
XBar
TX Q
846
slow path
forwarding
842
Xbar
402
FC

FIG 23

Simple Read

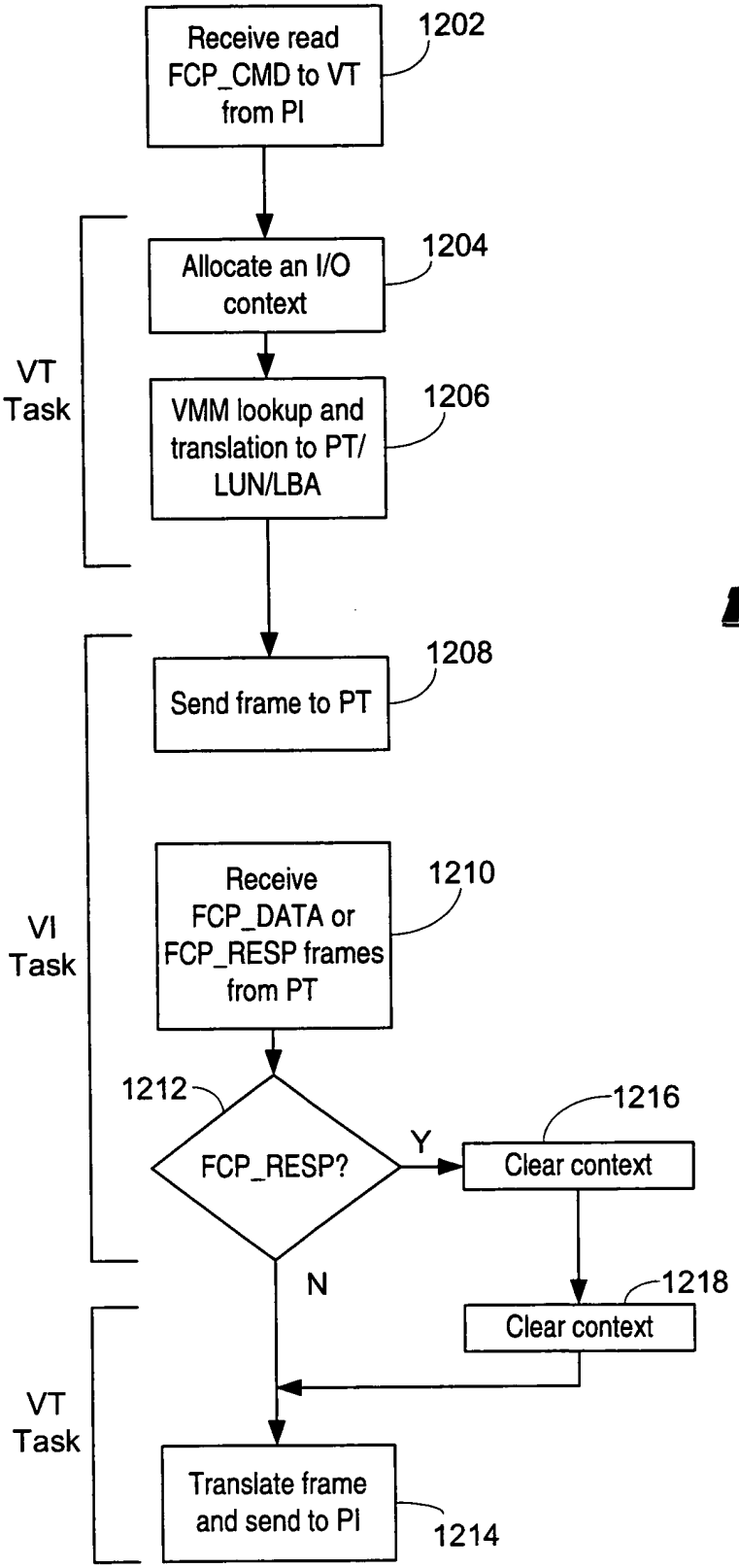

FIG. 24

Simple Write

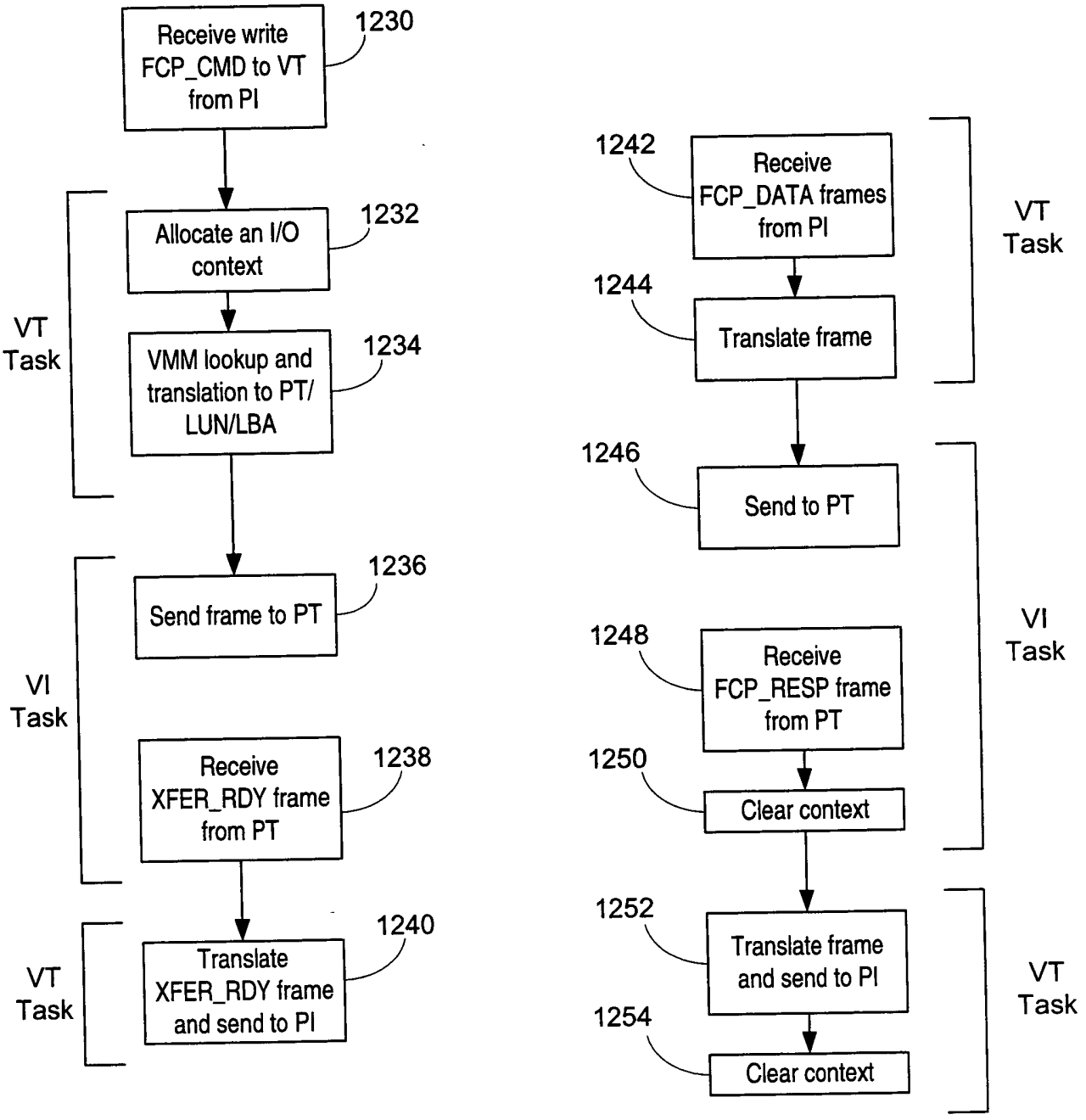

FIG. 25

Spanned Read

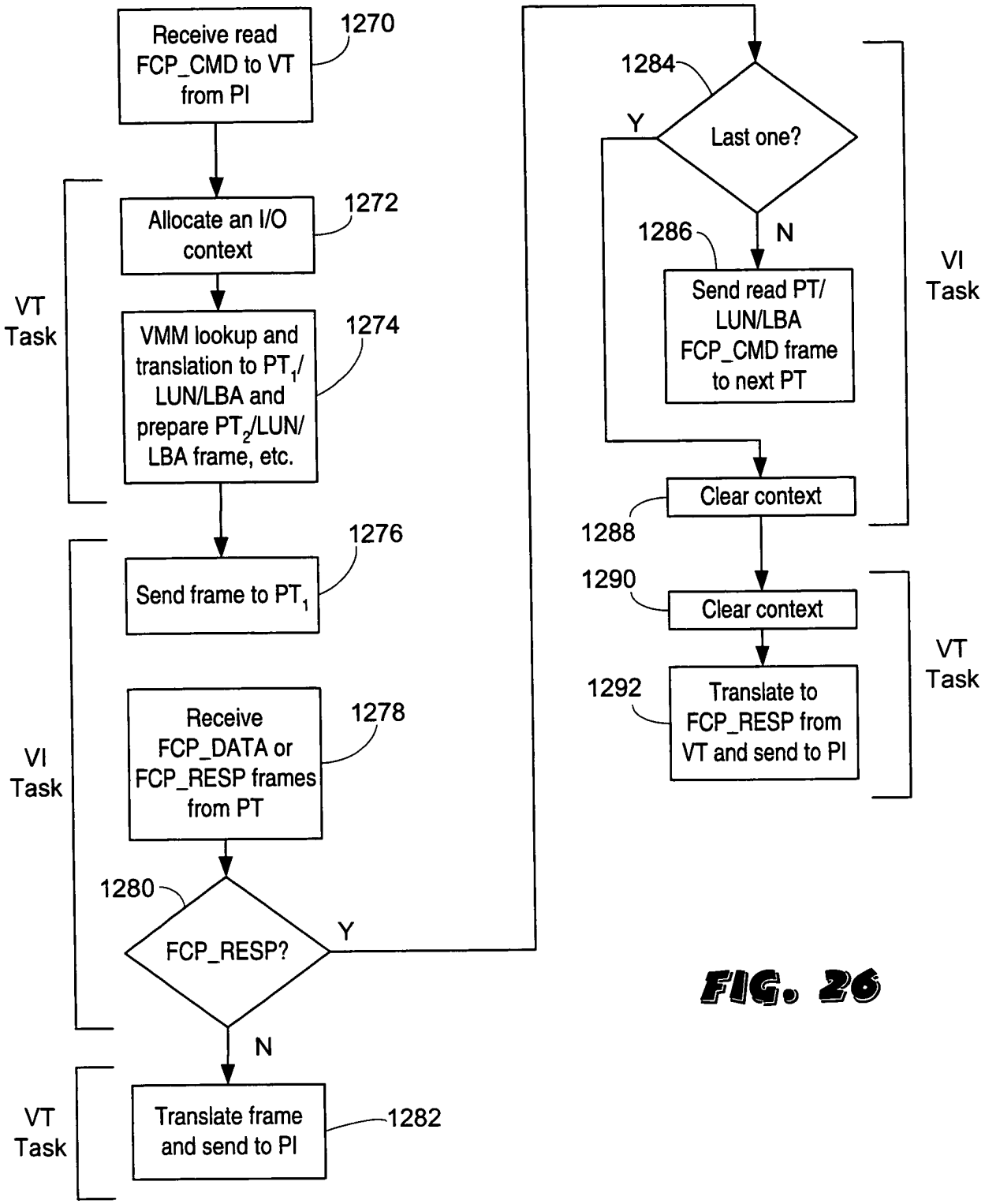

FIG. 26

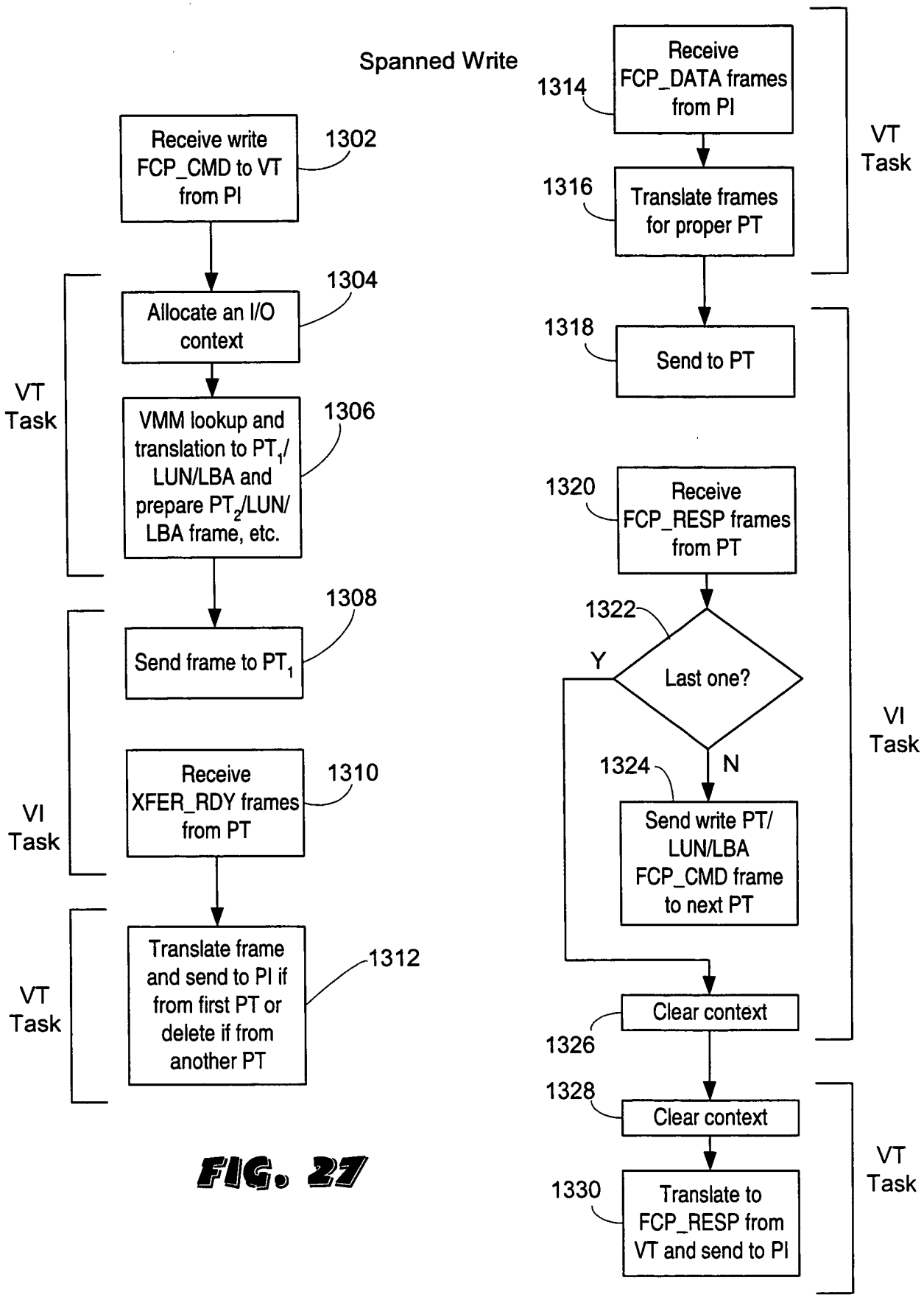
Spanned Write
Receive write FCP_CMD to VT from PI
1302
Allocate an I/O context
1304
VMM lookup and translation to PT1/ LUN/LBA and prepare PT2/LUN/ LBA frame, etc.
1306
Send frame to PT1
1308
Receive XFER_RDY frames from PT
1310
Translate frame and send to PI if from first PT or delete if from another PT
1312
VT Task
VI Task
VT Task
VT Task
Receive FCP_DATA frames from PI
1314
Translate frames for proper PT
1316
Send to PT
1318
Receive FCP_RESP frames from PT
1320
Last one?
1322
Y
N
Send write PT/ LUN/LBA FCP_CMD frame to next PT
1324
Clear context
1326
Clear context
1328
Translate to FCP_RESP from VT and send to PI
1330
VT Task
VI Task
VT Task

FIG. 27

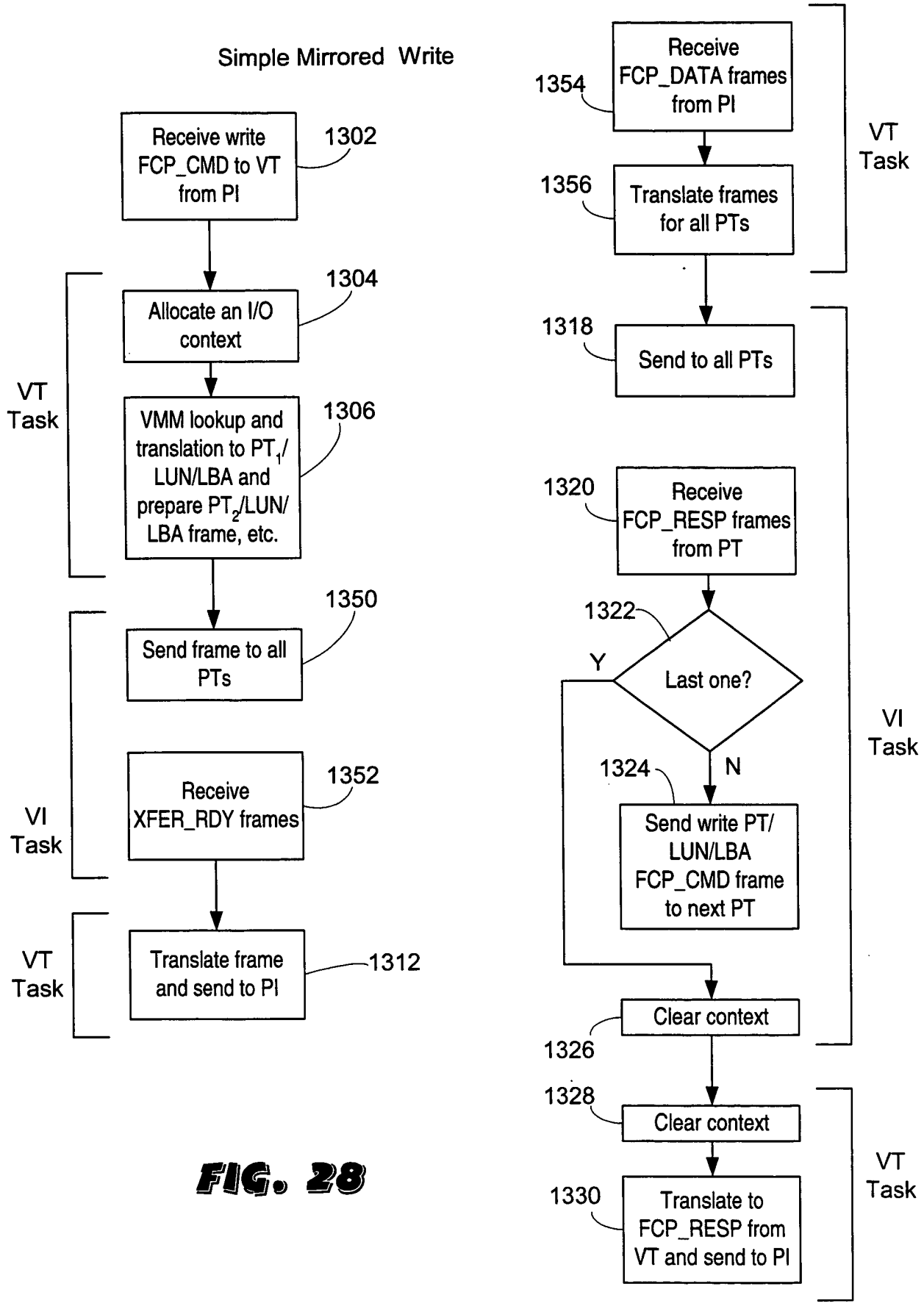
Simple Mirrored Write
Receive write FCP_CMD to VT from PI
1302
Allocate an I/O context
1304
VT Task
VMM lookup and translation to PT1/ LUN/LBA and prepare PT2/LUN/ LBA frame, etc.
1306
Send frame to all PTs
1350
Receive XFER_RDY frames
1352
VI Task
Translate frame and send to PI
1312
VT Task
Receive FCP_DATA frames from PI
1354
Translate frames for all PTs
1356
VT Task
Send to all PTs
1318
Receive FCP_RESP frames from PT
1320
Last one?
1322
Y
N
Send write PT/ LUN/LBA FCP_CMD frame to next PT
1324
VI Task
Clear context
1326
Clear context
1328
Translate to FCP_RESP from VT and send to PI
1330
VT Task

FIG. 28